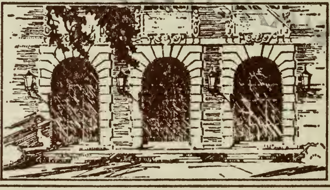

H F Bain Esq
with Author's Compts

REVISED

Pocket Geologist,

AND

MINERALOGIST

OR

SIXTEEN CHAPTERS

ON

Coals, Oils, Ores and Other Minerals,

FOR

Practical People who have Time to Make Money.

1890.

204 Pages—Cloth Bound—Flap Cover with Pocket.

PRICE ONE DOLLAR, Post Paid.

FREDERICK H. SMITH,
ENGINEER & GEOLOGIST,
227 E. GERMAN STREET, - - BALTIMORE, MD.

This Pocket Book is a revision and combination of the writer's two former volumes—the "POCKET GEOLOGIST," of 1877, and "ROCKS, MINERALS AND STOCKS," of 1882,—with some omissions, alterations and additions to bring it up to date. It is written, not for the scientist, but for practical people who have time to make money. It contains 204 pages, excluding index &c., is bound in cloth with pocket and flap, and is mailed postpaid on receipt of the low price of **ONE DOLLAR**, to cover its costs and charges, as it partakes of the nature of a professional card, and is intended to advance the writer's business as well as the reader's interests.

The writer's correspondence shows many instances of profitable mineral enterprises now being prosecuted by men who got their first ideas on mineral subjects from his two earlier volumes, and he expects even better results from this, as it is in better shape for convenient use. He will always be glad to hear from his readers concerning their mineral ventures, but he begs to remind them that all mail or express charges should be prepaid, that a chemist's assay costs, prepaid, from five to fifteen dollars, according to the number of elements determined, and that an engineer and geologist, also, requires some prepaid consultation fees when his professional opinion or advice is asked. But it is expected that the information contained in this new "POCKET GEOLOGIST" will, generally, enable the reader to answer his own questions.

F. H. S.

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CONTENTS.

I.

BOTTOM FACTS AND BED ROCKS.

Plain Language—Mineral Elements—Mineral Compounds—Igneous Rocks—Transition Rocks—Aqueous Rocks—Fossil Earmarks—Veins and Beds.

PLAIN LANGUAGE.

The following schedule of terms and definitions will be adhered to, as closely as possible, throughout this work:

LUSTRE.

The lustre of minerals is an important feature, and is to be determined from freshly-broken surfaces. The kinds of lustre are as follows:

Metallic is the lustre of polished surfaces of metals or freshly-broken surfaces. Imperfect degrees or slightly tarnished surfaces are sub-metallic.

Adamantine lustre is that of the diamond and that of other real gems. Sometimes it is clouded by the metallic.

Vitreous lustre is that of broken glass. Sub-vitreous is very common. White quartz is often vitreous, and marble is sub-vitreous.

Resinous lustre is that of the resins, balsams and clear gums.

Pearly lustre is that of pearl and mother-of-pearl, and is often modified by the metallic.

Silky lustre is the peculiar lustre of silk, and nearly always due to fibrous formation.

Lustre has degrees of intensity as well as kinds, but we will only state degrees when they are not changeable. They vary so greatly with the different angle or face of the mineral presented and the amount of light available that they are hardly useful.

TEXTURE.

Texture refers to the particular arrangement of the grains, crystals, sheets, blocks, or other bodies going to make up the mass of the specimen.

Massive texture is when the mineral is built up of grains so small as to be practicably indistinguishable by the unaided eye.

Granular texture is when the mineral is a mass of grains large enough to be seen.

Crystalline texture is when the mass is built up of one large crystal or many smaller ones, just large enough not to be called granular.

Foliated texture is when the mineral is a block made up of sheets or plates having one line of cleavage.

Fibrous texture is when the sheets are split up into fibres or strips by a second line of cleavage.

Tabular texture is when the block is a mass of smaller blocks, formed by three cleavage lines.

The massive, granular and crystalline textures are all granular, really, but the divisions are based on differences in size of grain. The foliated, fibrous and tabular textures are all really foliated, whichever way we turn the block, but the divisions are based on the shapes of the crystals, and the number of cleavage lines which have shaped them.

FEEL.

The "feel" of a mineral is a very useful distinguishing feature. The feels are named below:

Greasy is the feel of soapstone and other magnesian minerals, such as French chalk, talc, meerschaum, asbestos, etc.

Harsh is the feel of trachyte, pumice, basalt and other igneous rocks, but more especially of the lavas.

Meagre is the feel of the softer lime minerals, such as chalk, marl, etc.

CLEAVAGE.

Many minerals, by reason of crystallization or other causes, break into plates or blocks, the fractures occurring on parallel lines, and much more readily on those lines than in other directions. Minerals having one line of cleavage will separate into sheets. Two lines of cleavage split the sheets into four-sided bars or strips, and a third line of cleavage will cut off the ends of the bars, making blocks of them. All the faces formed by the cleavage lines are plane and smooth. There are but two full degrees of cleavage, perfect and imperfect, and intermediate degrees must be fractionally named, if expressed at all.

CLEARNESS.

Clearness is dependent greatly on the thickness of the specimen, as there are very few substances which cannot be hammered or shaved down so thin that they will transmit a certain amount of light, especially when examined under the microscope. Clearness is graded as follows:

Transparent is when outlines and details of objects can be seen clearly through the specimen. When the outlines alone, and no details, can be distinguished the specimen is semi-transparent.

Translucent is when light is transmitted through the body of a reasonably thick specimen, but no images are outlined. It is classed as semi-translucent when the light passes through the thin edges of a bevel-edged piece, but does not pass through the body of the specimen.

Opaque is when light is not seen by the naked eye to pass through any portion of the specimen.

ELASTICITY.

Nearly all minerals have more or less elasticity, and the degrees are stated as follows:

Elastic is when the mineral will spring back after having been bent. Mica is an example.

Flexible is when the mineral can be bent without breaking, but will not spring back of its own accord.

Malleable is when the mineral can be hammered out cold into sheets without crumbling.

Sectile minerals can be powdered under the hammer, but can be cut into sheets or slivers with the knife.

Brittle minerals break up when cut, bent or hammered.

HARDNESS.

This quality in minerals is very variable, and is most reliable and useful when tested with or on freshly broken edges or surfaces of homogeneous composition. Hardness is expressed in the following scale of ten degrees. Diamond, being the hardest known substance, is placed at ten, and other well-known substances occupy the full degrees:

Diamond	10	Apatite	5
Corundum	9	Fluorspar	4
Topaz	8	Calcite	3
Quartz	7	Gypsum	2
Feldspar	6	Talc	1

By testing strange minerals on any of those named in the table, the comparative hardness of the strange mineral is determined. It is to be observed that two minerals of equal hardness will scratch each other by using a sharp edge or corner of one against a surface of the other, and vice versa. Diamonds are thus cut by means of their own dust; the dust, consisting of minute grains all bristling with points and edges, cuts away rapidly the face of the massive crystal.

This is also true of minerals of *almost* equal hardness, the point or edge of the softest cutting slightly into the face of the hardest. Diamond can often be cut by corundum in this way. Frequent reversal of point of one to face of other, and point of other to face of one, and careful comparison, will give accurate results. Hardness of minerals will be given in this book in the descriptions.

COLOR.

Color is determined from observing the color of the powder-l specimen. The color of the mass very often differs from ıat of the powder, and the latter is the only reliable color. or instance, the iron ore limonite (commonly called brown ematite) is red, brown, purple, black or yellow in mass, but s powder is always yellow. The best way to determine olor is to file or grind off some powder and examine it when ing on a sheet of white or black paper or china or slate, ıt when the mineral is soft enough to leave a streak by bbing it on black slate or white china, that method is best. stating the colors of minerals we will use just such names we all understand.

FRACTURE.

Fracture refers to the appearance of the broken surface of mineral when freshly fractured across the line of cleavage lamination.

Conchoidal fracture is when the surfaces are roughly curved to concave and convex, somewhat like a ball-and-socket rangement.

Even fracture is when the surfaces are flat planes, but differ om cleavage planes in being spotted over with holes and ints.

Uneven fracture is when the rough points and holes cover whole fractured surface; in other words, the surface is ogether irregular and unsystematic, ragged and rough.

SPECIFIC GRAVITY.

This is the actual weight or *density* per cubic inch, or other it, of any substance when compared with the weight of same bulk of pure water. The specific weights of some ll-known substances are below:

SUBSTANCE.	GRAVITY.	SUBSTANCE.	GRAVITY.
Ice	0.94	Bituminous Coal	1.3
Fresh water	1.00	Anthracite coal	1.5
Sea water	1.03	Sulphur	2.0

SUBSTANCE.	GRAVITY.	SUBSTANCE.	GRAVITY.
Marble	2.6	Antimony	6.7
Aluminum	2.6	Zinc	7.2
Quartz	2.6	Tin	7.3
Talc	2.7	Iron, wrought	7.7
Feldspar	2.8	Cobalt	7.8
Flint Glass	3.0	Manganese	8.0
Fluorspar	3.1	Nickel	8.2
Diamond	3.5	Copper	8.9
Topaz	3.6	Silver	10.5
Corundum	4.0	Lead	11.4
Barytes	4.5	Mercury	13.6
Average of our Globe	5.2	Gold	19.3

The determination of the specific gravity of any substance is made by weighing a piece of dry mineral first in the air, and then weighing it again when submerged in water and suspended by the lightest possible thread or hair. If it weighs, say, ten grains in the air and eight grains in the water, the difference of two grains is the weight of the equal bulk of water which is displaced. The specific gravity of the mineral is, therefore, five (5.0), as the dry weight of ten is five times as great as the two grains weight of the equal bulk of water.

When the mineral is soluble in water but not soluble in alcohol or other fluid whose gravity is known, the mineral can be weighed in the other fluid, and the results reduced to the water scale. When a specimen contains two substances in known percentages, and the gravity of one of them only is known, the gravity of the other is a matter of simple arithmetic. When extreme accuracy is required, care must be taken to guard against changes in temperature, as even water changes slightly its density with thermal changes. Sixty degrees above zero on Fahrenheit's scale is the standard for air, water and mineral during the process when greatest accuracy is desirable.

Powdered or porous minerals must be allowed time to absorb all the water possible before the wet weight is taken. The air lodged in the cavities of the mineral tends to buoy up the mineral when it is submerged, and often it has to be boiled in order to expel this air. The rule is to have air in the cavities when the dry weight is being taken, and water in them when wet weight is taken.

The water molecules enter the cavities between the mineral molecules pretty much as a handful of small bird-shot will run down into a glass tumbler already full of large buck-shot, and yet another handful of fine, clean sand will run down into the cavities between the bird shot. An ounce or two of water can be poured into the tumbler to make sure of filling up the cavities between the sand grains, and a grain of cochineal will permeate between the water molecules and dye the whole affair scarlet. A speck of musk will perfume it all through by the same process, and it can still be charged with carbonic-acid gas or salt. And still the sub-atoms of the ethereal medium may be ebbing and flowing through glass, lead, water, sand and all, as easily as an evening zephyr would pass through a shad seine hung out to dry. The so-called supernatural may be only natural, after all.

MINERAL ELEMENTS.

At present, the chemists have segregated and named sixty-four elements or simple substances out of which this entire globe, and all its contents and belongings of the mineral, or vegetable, or animal kingdoms, are made up. The names, symbols and atomic weights of these elements are as follows:

NAME.	SYMBOL.	ATOMIC WEIGHT.
Aluminum	AL	27.3
Antimony	Sb	122.
Arsenic	As	75.
Barium	Ba	137.
Bismuth	Bi	208.
Boron	B	11.
Bromine	Br	80.

Name.	Symbol.	Atomic Weight.
Cadmium	Cd	12.
Cæsium	Cs	133.
Calcium	Ca	40.
Carbon	C	12.
Cerium	Ce	92.
Chlorine	Cl	35.5
Chromium	Cr	52.
Cobalt	Co	59.
Columbium (Niobium)	Cb (Nb)	94.
Copper	Cu	63.4
Didymium	D	96.5
Erbium	E	112.6
Fluorine	F	19.
Gallium	Ga	....
Glucinum (Beryllium)	G (Be)	9.
Gold	Au	196.
Hydrogen	H	1.
Indium	In	113.4
Iodine	I	127.
Iridium	Ir	198.
Iron	Fe	56.
Lanthanum	La	92.5
Lead	Pb	207.
Lithium	Li	7.
Magnesium	Mg	24.
Manganese	Mn	55.
Mercury	Hg	200.
Molybdenum	Mo	96.
Nickel	Ni	59.
Nitrogen	N	14.
Osmium	Os	200.
Oxygen	O	16.
Palladium	Pd	106.
Phosphorus	P	31.
Platinum	Pt	198.
Potassium	K	39.
Rhodium	Ro	104.
Rubidium	Rb	85.4
Ruthenium	Ru	104.
Selenium	Se	79.
Silver	Ag	108.
Silicon	Si	28.
Sodium	Na	23.
Strontium	Sr	38.
Sulphur	S	32.

NAME.	SYMBOL.	ATOMIC WEIGHT.
Tantalum	Ta	182.
Tellurium	Te	128.
Thallium	Tl	204.
Thorium	Th	231.
Tin	Sn	118.
Titanium	Ti	50.
Tungsten	W	184.
Uranium	U	240.
Vanadium	V	51.4
Yttrium	Y	61.7
Zinc	Zn	65.
Zirconium	Zr	90.

The above-named substances are called elements because science has not yet succeeded in splitting up any one of them into atoms of two or more of the others; but how soon this will be done we can't tell. Already an Austrian chemist has announced that the exact atomic weights of a large number of the elements bear a multiple relation to those of the four chief elements: oxygen, carbon, nitrogen and hydrogen. He thinks that eventually all the other elements will be shown to be derived from these four in different combinations, and that possibly these four may be reduced to hydrogen only, or to some one still unknown.

At present the physical conditions of the different substances are very various. Oxygen, hydrogen and nitrogen are supposed to be fixed gases. Fluorine and chlorine are also gases, but can be liquefied. Bromine and mercury are liquids easily vaporized, while the others are solid at ordinary temperatures.

MATTER AND ENERGY.

The word matter includes within its meaning all substances of all kinds known to the senses or to the imaginations of of men, whether those substances be solid, liquid, vaporous, gaseous or ultra-gaseous, whatever that may mean. All experience goes to show that matter is indestructible by any agency, but whether or not that indestructibility reaches backward or forward into the Infinite we can know nothing about. We have no evidence at all bearing on the case, so we take it as we find it, and we find that although we can change matter from one condition to another condition, we cannot destroy it nor change any one kind of matter into another kind of matter. Iron will be iron, whether solid, liquid or gaseous, and that is about as far as we have got.

The word energy includes within its meaning all forms of force, active or latent, such as heat, light, motion, weight, cohesion, repulsion, attraction, electricity, magnetism, affinity and all other forms and sub-forms and appearances. Energy, like matter, is indestructible so far as we know, but we can change one kind of energy into another, and so on through the list, without having annihilated it, or left any of its units unaccounted for.

ATOMS AND MOLECULES.

Matter is infinitely divisible; its attribute, energy, accompanies it down through all its subdivisions, and we are unable to conceive of any particle of matter so small but that it may be composed of two or more still smaller particles held together by some form of energy. For practical purposes, however, we must assume a temporary stopping place in this process of subdivision, so we call that a *molecule* which is supposed to be the smallest particle of any one substance which retains all the properties of the same substance in larger parcels. This molecule is the physical unit, and all larger amounts of the same substance are simply bundles or agglomerations of these molecules.

These molecules themselves are divisible into two or more smaller particles called *atoms*, which are the chemical units of matter, and are supposed to contain only the chemical forms of energy. Thus water is a mass of molecules, each one being the smallest bit of water that can exist and still have weight, fluidity, wetness and all the other properties of water. This molecule contains three atoms, viz.: one of oxygen and two of hydrogen, which are held together by chemical energy. The water molecule is a compound molecule, composed of atoms of different elements or substances; but there are simple molecules composed of enough atoms of any one substance to develop physical energy. The elements whose molecules are thus variously built up are called monatomic, diatomic, triatomic, etc. Atoms do and molecules do not combine with each other chemically, while molecules do and atoms do not unite with each other mechanically.

In addition to the list of elements, there is a partially known substance called the ethereal medium, which fills all space. Some think it to be an ultra-gaseous condition of matter which is sub-atomic, and devoid of both chemical and physical energy, and of absolutely perfect fluidity.

SYMBOLS AND ATOMIC WEIGHTS.

The atomic weights of the elements are the weights or quantities of each required in order to combine with one weight unit of hydrogen in making up into molecules. The atomic weights are thus the combining weights of the elements, and have no reference to actual weight per inch or other unit of volume.

The symbols shown in the list of elements are convenient abbreviations used by all chemists, and are generally derived from the Latin names.

The symbols and atomic weights are used entirely in writing or figuring formulæ. Thus the formula $Fe_7 S_8$ expresses nearly all that is essential to know about a lump of magnetic pyrites. It shows it to be a mass of molecules, each of which contains seven atoms of iron and eight atoms of sulphur. Now, by multiplying each of these numbers of atoms by the respective atomic weights, we find that the mineral contains 392 parts by weight of iron and 256 of sulphur, which is substantially sixty per cent. of iron and forty of sulphur.

MINERAL COMPOUNDS.

There are three classes of minerals or mineral compounds, and although the varieties in minerals are almost uncountable, they are all reducible to one of three classes. These are as follows:

Natives are masses of simple molecules of a single substance or conglomerations of simple molecules of different substances mechanically intermixed but not chemically combined. Such are the native metals, the alloys and the amalgams.

Binaries are compound molecules, each composed of the atoms of two elemental substances chemically united. Such are the sulphides, chlorides, oxidés, etc.

Ternaries are compound molecules, each composed of the atoms of two elements chemically united indirectly by or through atoms of a third element. Such are the silicates, carbonates, sulphates, etc.

PRINCIPAL BINARY COMPOUNDS:

Water.

This is Hydrogen Oxide,

Composed of Hydrogen,	.	11 per cent.
" Oxygen,	.	89 "

Lime.

This is Calcium Oxide,

Composed of Calcium,	. .	72 per cent.
" Oxygen,	. .	28 "

Magnesia.

This is Magnesium Oxide,

Composed of Magnesium,	. .	60 per cent.
" Oxygen,	.	40 "

Soda.

This is Sodium Oxide,

Composed of Sodium,	. .	74 per cent.
" Oxygen,	. .	26 "

Potassa.

This is Potassium Oxide,

Composed of Potassium,	.	83 per cent.
" Oxygen,	.	17 "

Alumina.

This is Aluminum Oxide,

Composed of Aluminum,	.	53 per cent.	
" Oxygen,	.	47 "	

Silica—Quartz.

This is Silicon Oxide,

Composed of Silicon,	. .	47 per cent.
" Oxygen,	. .	53 "

The foregoing seven minerals are all binary compounds, and they constitute about 98 per cent. of all the crust of our globe.

The next steps in building up the globe are the

PRINCIPAL TERNARY COMPOUNDS,

which are as follows, and are mostly silicates, and come in groups:

Mica.

This is a large group, the principal members of which are named *Biotite*, *Phlogopite* and *Muscovite.* The latter is the most common and abundant, and is selected for description.

Gravity	2.7 to 3.1	Potassa	9 p. ct.
Hardness	2.0 to 2.5	Water	4 p. ct.
Alumina	34 p. ct.	Sundries	6 p. ct.
Silica	47 p. ct.		

Lustre, pearly; clearness, translucent to transparent; color, white, green, yellow, black; feel, smooth; elasticity, flexible to elastic, cleavage, perfect; fracture, uneven; texture, foliated.

The coloring matter of the micas is usually iron, and often a part of the potassa is replaced by soda. Mica is one of the principal ingredients of the true granite, in which rock it is easily distinguished in little bundles of plates or scales. Sometimes it is in large pockets in granite or gneiss rocks, and then can be split up into transparent plates, which are used for stove plates or windows. Some people call it *isinglass.*

Feldspar.

There are many feldspars, the principal ones being *Anorthite*, *Labradorite*, *Albite*, *Oligoclase*, *Orthoclase*, *Andesite*. The orthoclase is most abundant, and is therefore selected for description.

Gravity	2.7 to 2.9	Alumina	17 p. ct.
Hardness	5.8 to 6.1	Potassa	17 p. ct.
Silica	65 p. ct.	Dirt, etc	1 p. ct.

Lustre, pearly to vitreous; clearness, translucent; color, white, red, green, pink; feel, smooth to harsh; elasticity; brittle; cleavage, perfect in three directions; fracture, uneven; texture, tabular.

Feldspars occur in thick plates and tabular masses, which break up into small, nearly cubical blocks. The light flesh color is most abundant, but the colors are always blotched. Feldspar often forms great rock masses, mostly parts of dykes porphyritic in texture, or in sheets of overflow. It is also one of the three constituents of granite. When a bed of feldspar decomposes, the potash or other alkali washes out and the silica and alumina remain behind as *kaolin* or porcelain clay. Some of the feldspars have lime or soda or magnesia instead of potassa.

Hornblende.

This group is sometimes called the *Amphibole* group, the principal members being *Tremolite*, *Actinolite*, *Smaragdite*, *Asbestos*, *Hornblende*. The latter being much the most abundant is here described:

Gravity	3.0 to 3.3	Magnesia	13 p. ct.
Hardness	5.0 to 6.0	Lime	12 p. ct.
Silica	45 p. ct.	Iron	12 p. ct.
Alumina	13 p. ct.	Potassa and Soda	5 p. ct.

Lustre, pearly to vitreous; clearness, from transparent all the way to opaque; color, green, brown, black; feel, smooth to harsh; elasticity, brittle; cleavage, imperfect to perfect; fracture, conchoidal to uneven; texture, granular, but sometimes slaty or fibrous or columnar

Magnetism is sometimes present, due to the iron. True hornblende is often found in bundles of hexagonal crystals. It is a constituent in syenite, which is the hornblendic granite. It also forms some large rock masses, portions of dykes or overflows.

Augite.

This is the most abundant of the *Pyroxene* group, the others being *Diallage*, *Sahlite*, *Malacolite*, *Leucagite*. The description of augite is this:

Gravity	3.2 to 3.5	Magnesia	13 p. ct.
Hardness	6.0 to 6.5	Alumina	7 p. ct.
Silica	50 p. ct.	Iron	7 p. ct.
Lime	22 p. ct.	Soda, etc	1 p. ct.

Lustre, resinous to vitreous; clearness. sub-translucent to opaque; color, green, brown, black; feel, smooth to harsh; elasticity, brittle; cleavage, imperfect; fracture, conchoidal to uneven; texture, granular and sometimes crystalline in hexagonal prisms, shorter than hornblende. Augite decomposes into bodies of greenish earth, which fill cavities in the rocks of which it is a constituent.

Epidote.

This is the principal member of its own group, and other members are *Allanite*, *Ilvaite*, *Zoisite*. The description of *Epidote* is as follows:

Gravity	3.1 to 3.4	Alumina	22 p. ct.
Hardness	6.0 to 6.4	Iron	12 p. ct.
Silica	38 p. ct.	Water, etc	3 p. ct.
Lime	25 p. ct.		

Lustre, vitreous; clearness, translucent to opaque; colcr, yellow, green, brown, black; feel, smooth; elasticity, brittle; cleavage, imperfect; fracture, uneven; texture, granular, and very rarely is it crystalline, fibrous or foliated.

Epidote is abundant in the prime and in the primary rocks, and is generally associated with hornblende. The fine granular epidote sometimes forms rock masses of considerable size.

Talc.

This group contains *French Chalk*, *Meerschaum*, *Steatite* or *Soapstone* and *Talc*, which is here described:

Gravity ....2.4 to 2.7	Magnesia..............32 p. ct.
Hardness............1.0 to 1.2	Water............... 4 p. ct.
Silica............... 64 p. ct.	

Lustre, pearly; clearness, translucent to opaque; color, white, gray, green, brown; feel, greasy; elasticity, flexible to brittle; cleavage, perfect; fracture, conchoidal to even; texture, massive, granular or foliated, sometimes looks like starry radiations as seen in magnesian marble.

Talc is the most abundant of all the great magnesian silicates. The principal gold regions of the world are among the talcose slates of the Primary Formation.

Serpentine.

Other members of this group are *Bastite*, *Cerolite*, *Gymnite*, *Marmolite*. The points on Serpentine are:

Gravity...............2.5 to 2.8	Magnesia..............43 p. ct.
Hardness............3.0 to 3.7	Water .... 13 p. ct.
Silica................ 44 p. ct.	

Lustre, pearly; clearness, translucent to opaque; color, green; feel, smooth to harsh; elasticity, flexible to brittle; cleavage, imperfect; fracture, uneven; texture, granular.

Serpentine is very abundant among the primary rocks, and amounts to an eruptive rock all by itself, showing in dykes and round-backed ridges and hills. It is much in favor as a fancy building stone, and properly handled it produces very fine architectural effect. When very bright green and capable of taking high polish it is much used for mantels and other interior work and is called "Precious" Serpentine. When it is streaked with magnesian marble it is called "Verde Antique," and will be referred to further along in this book.

CHRYSOLITE.

Other members of this group are *Monticellite*, *Wohlerite*, *Fayallite*, but *Chrysolite* itself is much the most abundant, and is here described:

Gravity..............3.3 to 3.5	Magnesia.............50 p. ct.
Hardness............6.0 to 6.8	Iron Oxide........... 8 p. ct.
Silica................ 42 p. ct.	

Lustre, vitreous; clearness, translucent; color, yellow, green, brown; feel, harsh; elasticity, brittle to very tough; cleavage, imperfect; fracture, conchoidal; texture, granular.

Chrysolite is usually found in dykes and pockets, but they are large and form great bodies. It is the home of corundum and emery. Some little magnetism has been observed, owing to the presence of the iron. Chrysolite is found in the mountains of North Carolina in very large bodies.

CHLORITE.

The principal members of the *Chlorite* group are *Penninite*, *Prochlorite*, *Margarite*, *Ripidolite*. The last is the important one, and is here described:

Gravity..............2.6 to 2.7	Magnesia.............36 p. ct.
Hardness............2.2 to 2.3	Alumina..............18 p. ct.
Silica.... .... 32 p. ct.	Water, etc.............14 p. ct.

Lustre, resinous to pearly; clearness, translucent; color, green to slightly reddish; feel, smooth to harsh; elasticity, flexible to brittle; cleavage, perfect; fracture, even to slightly uneven; texture, massive to granular and scaly.

Chlorite is very abundant among the primary rock formations, and the chlorite slates are nearly as famous as gold-bearing rocks as are the talcose slates. The chlorite slates are generally greener and brighter than the talcose slates, don't feel so greasy either, and are generally found overlying the talcs, although sometimes they lie in alternating strata.

These nine ternary compound minerals will be further referred to in the chapters treating of their economical values, when they have any, but at present they are described as constituent minerals composing the igneous rocks.

IGNEOUS ROCKS.

These rocks, called also the eruptive rocks, are supposed to come from the earth's interior or core rock, and they are the first aggregations of the great constituent binary and ternary compound minerals. These minerals are aggregated in these rocks in varying proportions, so that no full descriptive list can be made of them, but their names and general compositions and characters are about as follows:

LAVA.

These igneous or erupted rocks of all kinds are called *Lava* when they are of light weight and porous or frothy or ashy in structure, and some kinds are called *Pumice.* These rocks are found mostly around volcanoes, ancient or modern. Glassy lava is called *Obsidian.*

TRAP.

Trap rocks are any kind of igneous or erupted rock which is laid down in sheet upon sheet, the edges looking like steps of a staircase, while lava is generally the result of violent eruption. Trap is produced by a slow and dignified outpouring of melted rock. Trap rocks containing pebbles or other spherical cavities, where pebbles might have been, are called *Amygdaloidal.*

BASALT.

This consists of the minerals feldspar, augite and chrysolite, in various proportions, and there is often some iron. It is a dark gray or greenish gray rock, very crystalline and finely granular in texture, and nearly always it is in columns of six sides, standing up vertically or inclined, and often lying horizontally. There are dykes of it in Alabama and elsewhere which stand up four or five feet above the ground, and look like piles of cord-wood. Fingal's Cave and the Giant's Causeway in Europe, and the Palisades of the Hudson River, or Thunder Cape on Lake Superior, are noted localities.

DOLERITE.

This consists of feldspar and augite with some iron, and is the same as basalt with the chrysolite omitted. It is, therefore, not so greenish as basalt, and the augite, not having so tenacious a combination with other minerals, is apt to decompose into greenish earth which washes out and leaves the dolerite full of cells and pores—looks pockmarked. It has the same tendency to crystallize into six-sided columns as basalt, and is often mistaken for it.

DIORITE.

Diorite is often called *Greenstone*, but this name is more properly applied to this same rock after it has been washed down and deposited as one of the primary rocks and melted up again and re-crystallized into a massive rock. It is abominably hard and tough in any condition, and is greenish gray in color, or rather gray mottled with green. It is made up of hornblende and feldspar.

TRACHYTE.

This is a very harsh-feeling, porous and light-weight rock composed of feldspar with some hornblende and a very little mica in small particles. Its color is generally pale-gray or pale-blue, but it is sometimes yellowish or reddish.

PORPHYRY.

True porphyry is composed entirely of feldspar, the arrangement being a number of large crystals of feldspar embedded in the cement of the same material. It is an agglomerate, whereas it is often the case that conglomerates are called porphyry by men who ought to learn better. The *agglomerates* are those in which the pebbles and the cement are the same materials, while in *conglomerates* they are of different materials.

These igneous rocks are principally visible to the naked eye, disposed in sheets intercalated between the beds of the great primary formations, and sometimes in the secondaries and tertiaries; and they sometimes exist as the very top rocks in those volcanic regions where the lava beds cover many hundreds of square miles; and sometimes they form mountains.

When our little Earth was sufficiently cooled down to permit the great bulk of the fiery gases to condense into liquid form, and this liquid was nearly ready to congeal into solid rock, the globe took its final form; that of a ball slightly flattened at the poles and bulged out several miles at the Equator, being exactly the shape given to a ball of red-hot glass by revolving it rapidly on a spindle.

As our red-hot globe continued to cool down, its diameter contracted, and its surface congealed into crusts which were wrinkled up into ridges as the globe shrunk up. These crusts were continually being cracked and broken up and overlapped on each other, and covered by fresh sheets of melted rock poured out from the interior through the cracks, and these again cracked and covered and re-covered until the surface was sheet upon sheet piled flatwise, endwise, sidewise, edgewise, and every otherwise, like the structure of an ice gorge in a big river.

As the original gases contained the atoms of all these substances belonging to our globe, and as all these substances do not liquefy at the same temperature, it is plain that when the surface of the globe was congealing into crusts there must have been fiery clouds of unliquefied gases hanging up overhead. These gases have all been gradually absorbed into the globe except the atmospheric air, which doubtless will remain unabsorbed until we have no more use for it.

When the lowering temperature reached the proper point, the oxygen and hydrogen in the fiery clouds combined with each other and formed superheated steam, which in time cooled and condensed into water, and descended during long ages as scalding-hot rain, which blistered and scalped off the surfaces of the hot rocks, and was driven up again as steam. As the rocks further cooled down, the water could begin to collect in the depressions and form boiling lakes, from which the steam constantly arose, only to fall again elsewhere as hot rain, and scalp off more rock materials, and wash them down into the depressions.

It is possible that nearly all the materials out of which the sedimentary rocks are now formed were originally scalped off the core rock of the globe during these early days of steam, hot water and violent upheavals, and that the work done since those days has been principally the re-washing re-arranging and re-depositing over and over again of the same old debris. The violent upheaval of the bottom of a sea or lake, accompanied by a neighboring depression of corresponding size, the rush of the water from the old sea to the new, and the simultaneous outpouring of a half an ocean of red-hot lava into the water, must have been rather immense.

The globe has continued to lose its heat until the present time, and it has also continued to shrink in size. The crust has also continued to thicken, and it must have thickened downwards by the addition to its underside of materials solidified by cooling out of the molten interior. This thickening enables the crust to withstand greater and greater accumulations of strain from globe shrinkage, and this in turn lengthens the intervals between the upheavals and earthquakes caused by the crushing of the abutting edges of the earth crusts.

This crushing and giving way always takes place along the line of least resistance, and one shock or series of shocks so weakens such materials as it does not crush that the next shock breaks up the already weakened materials. We find, therefore, that earthquakes are confined to certain countries, while other regions are free from them. This has been the case as far back as our histories reach, and it is probable that modern quaking and volcanic regions are the same as those in which this kind of action took place most frequently and violently in the earlier days; but it is probable that in the still earlier days these upheavals and crushings were scattered and without systematic arrangement on lines of least resistance.

As the intervals of time between the great earthquakes and upheavals became longer, the disturbances became greater, owing to the increased amount of accumulated resistance to be overcome all at once. This is verified by reference to all the great mountain ranges of the modern world. The Himalayas, Alps, Rockies and Andes have been the result of comparatively modern upheavals, as they all have recently-formed rocks and clays high up near their summits, which sedimentary beds must have been formed by deposition of sand, silt and shells under water before the upheavals took place. The shells are all the shells of salt-water species of Jurassic or later ages.

It was a wise old darkey deacon who cherished a mental reservation on the subject of Omnipotence being equal to the task of making two hills without a hollow between them. When a rubber football is sealed up in summer with warm air in it, it is round and plump, but when winter comes the contained air cools and contracts, the surface of the ball collapses and falls in, shaping itself into one or more dimples with raised edges. Just so, as the molten interior of the globe cools and contracts, the crust falls in, in spots, and the edges are raised up. The spots are the oceans and the raised edges are the mountain ridges, and the portions neither raised nor sunken are the great continental plains and tablelands.

Easter Island, in the Pacific Ocean, is a towering peak of black granite standing out of water many hundreds of miles away from any other land. Every square foot of the peak above water is carved into most grotesque forms, and there are many idols thirty feet high, facades of temples, altars, etc., and the carvings extend down under the surface of the sea as deep as can be seen with the aid of the water glass through the clear water. This peak is thought to have been the central religious shrine of the people inhabiting a great continent which was engulphed in pre-historic times. There are indications that there was a similar collapse of a continent in the Atlantic Ocean also.

If great continents collapse and go down under the sea, other great continents must have come up out of the sea about the same time to preserve the equilibrium. The word "cataclysm" has been used to describe the smash that takes place at such times. Just consider what a cataclysm that must have been when those two continents were engulphed, and the great mountain ranges above mentioned were upheaved, and probably large portions of their continents with them. What became of the old empires and republics, party platforms and propriety, iron-clad ships, bridges and creeds, stock markets, women's rights and national debts?

There is consolation for us in the thought that perhaps the earth's crust has now become so thick that the shrinkage force cannot hereafter crush it seriously, and will expend itself in splitting up the interior of the earth into radial-shrinkage cracks like those seen in broken cannon balls. Our modern earthquakes and volcanoes are probably due to local overstrains in portions of the outer crust, the over-strain being probably a residuum left over from the last general quake, acting on weakened strata.

TRANSITION ROCKS.

But while the foregoing lavas, traps, diorites and porphyries are the true igneous or eruptive rocks, there is another class of rocks which have been washed off from the surface of the igneous rocks, and laid down in beds by the action of water, and have been afterwards subjected to such great heat that all the water has been burned out of them; these are the metamorphic or transition rocks, and they have been held in the heated condition so long, that many of them are truly crystalline while some of them have been actually melted, and thus their original stratification has been lost, and they have cooled down into massive blocks with irregular lines of cleavage. These transition rocks constitute the great primary formation, which is the only one of the geological formations which extends in greater or less force everywhere around the globe.

We must, in studying formations, constantly bear in mind that, as a general proposition, all those portions of the earth's crust that were above water at any given period were being cut down, and all those portions that were below water at that time were being filled up. This is modified by the fact that submerged coast lines were being cut down by shore currents, and upland valleys were occasionally having temporary deposits made in them; but these modifications were confined to spots, and were only temporary effects.

This accounts for the fact that, although the different rock formations are piled on top of each other, like the leaves of a book, yet nowhere do we find the book complete. A portion of a leaf is torn out here, and a portion of another leaf is torn out there, and so on, all down through the whole thickness of the book, so far as we have yet discovered.

There is always enough left of any one leaf to show that such a leaf existed, and this is made of the materials which were laid down under water during that particular age which it represents. The materials were taken from the uplands of that age, and were torn out of the exposed portions of earlier leaves.

The "Geological Column," shown on next page, gives the succession of the rocks, as they have been determined by Geologists all over the world. Some few of the beds and groups are not yet recognized in America. The names are mostly those applied by the New York Geological Survey, and it is customary in this country to refer the beds of other localities to this survey when they are sufficiently identified, although these beds may be named locally for local use.

The rocks enumerated on the column, taken in their greatest thickness respectively, aggregate about fifteen miles from the top to the lowest known depths.

The Roman numerals and Latin names in the middle column of the Geological Chart represent the system used by the Rogers Brothers, in their Virginia and Pennsylvania Reports, and these are often referred to by geologists.

Cenozoic.	Quaternary.	Mammals.	Uncompact.	Alluvial.		Soil, Sand, Clay, Peat.
				Diluvial.		Drift Clay, Boulders, Glacial.
	Tertiary.			Pliocene.		Sand, Clay, Marl, Lignite.
				Miocene.		" " " "
				Eocene.		" " " "
Mesozoic Life.	Secondary.	Age of Reptiles.	Cretaceous.	Upper Chalk.		Marl, Clay, Flints, Lignite,
				Lower Chalk.		" " " "
				Upper Sand.		Green Sand Marl "
				Lower Sand.		" " " "
			Jurassic.	Wealden.		Limestone, Sand, Clay.
				Upper Oolite.		Fish Egg Limestone.
				Middle Oolite.		" " "
				Lower Oolite.		" " "
				Upper Lias.		Clay, Shale, Limestone.
				Middle Lias.		Shell Marl.
				Lower Lias.		Limestone, Bones, &c.
			Triassic.	Keuper.		Shales, Lime, Sand, Coal.
				Musclechalk.		" " " "
				Bunter Sand.		New Red Sandstone, "
Paleozoic or Ancient Life.		Coal Plants.	Carboniferous.	Permian.		Shales, Marl, Gypsum.
				Upper Coals.	XIII. Coal Measures.	Mahoning Sandstone, Coals.
				Lower Coals.		Shales, Coals, Limes, Sands.
				Millstone Grit	XII. Seral.	Mountain Conglomerate.
				Mount'nLimestone	XI. Umbral.	Limestones, Shales.
				Pocono.	X. Vespertine	False Coals, Brk'n Bed Sandstone.
		Age of Fishes.	Devonian.	Catskill.	IX. Ponent.	Old Red Sandstone, Brownstone.
				Chemung.	VIII. Vergent or Cadent.	Coarse Gritty Shale.
				Portage.		Sandstones, Shales.
				Gennessee.		Shales, Slates.
				Hamilton.		Shales, Flagstones.
				Marcellus.		Bituminous Shales.
				Upper Helder.		Flinty Limestones.
				Schoharie.		Limestones, Sandstones.
				Cauda Galli.		Cocks-tail Sandstones.
				Oriskany.	VII. Meridial	Coarse Pebbly Sandstones.
		Age of Mollusks.	Silurian.	Lower Helder.	VI. Pre-Merid.	Limestones.
				Saliferous.	V. Scalent or Surgent.	Onondaga Salt Group.
				Niagara.		Limestone Shales.
				Clinton.		Sandstone, Limestone; Red Iron Ore.
				Medina.	IV. Levant.	Hard Mountain Sandstone.
				Oneida.		Conglomerate.
				Hudson.	III. Matinal.	Shales.
				Utica.		Shales.
				Trenton.	II. Auroral.	Birdseye Limestone; Gas.
				Chazy.		Limestone.
				Calciferous.	I. Primal.	Blue Limestone.
				Potsdam.		Mountain Sandstone, Iron.
Eozoic.	Primary	Fungi.	Crystalline.	Huronian.	Metamorphic or Transition Rocks.	Slates, Schists, Marble.
				Montalban.		Gneiss, Schists, Granites.
				Labradorian.		" " "
				Laurentian.		" " "
Azoic or lifeless time, Chaos.					Plutonic.	Igneous Core of the Globe.

The transition or primary rocks make a rather small show at the bottom of the Geological Column, but the four groups aggregate in thickness some eight or nine miles from the bottom of the secondary down to the lowest known point, but how much further down it is to the contact with the azoic or core rock we don't know.

The kinds of rock included in the primaries are as follows, and they are all crystalline:

PEGMATITE

Is a very coarse-grained, ill-regulated rock, made up of feldspar and quartz in very large crystals, and a little mica. The color is most frequently yellowish, and the crystals are so large that it is at times sub-translucent.

GRANITE

Is built up of well-regulated crystals of feldspar, quartz and mica, and it is called granite because it is so perfectly granular. The quartz is generally white, the feldspar white or pinkish, and the mica is usually lead-colored but often dark brown or even black, and gives ruling color to the mass, except in the red or Scotch granite, where the color is due to red feldspar.

SYENITE.

This is hornblende granite, the hornblende being in place of mica in the true granite. It is more apt to be darker in color and considerably finer in grain than the micaceous granite. It is found in great sheets and masses like granite. This stone is the Egyptian black granite.

PROTOGENE.

This is talcose granite, the talc replacing the mica in this stone, just as hornblende replaces it in syenite. It is, of course, granular, and occurs in great sheets and masses. The substitution of talc for mica gives it a slightly greenish tinge.

GNEISS.

This is made up of any of the minerals contained in the foregoing granular rocks, but when gneiss contains mica it does not often contain either talc or hornblende. When containing hornblende it generally omits mica and talc. When talc is present, mica and hornblende are mostly absent. This shows that gneiss is either washed down granite, syenite or protogene, or else the granites are melted gneiss. The gneiss is evidently a sedimentary rock, as it is coarsely and irregularly stratified, and there are reasons for holding that it is part of the original sedimentary rocks scalped off in the earliest days.

Gneiss fades upwards into the finer grained and more perfectly stratified schists; downward into the highly crystalline, granular granite rocks, and horizontally it fades into granite also. There are cases where granite rocks rest on top of gneiss, separated therefrom by a sharp line of contact, which shows that the granite overflowed the gneiss in a sheet or stream from some neighboring fissure. Other cases show the gneiss on top of the granites with equally sharp line of contact, which shows that there had been a second sedimentary deposit on top of the granite formed by the melting of a former bed of gneiss. Still other cases show the gneiss fading downwards and laterally also gradually into granite, which show that the second heating up was not sufficiently intense to melt up the whole mass of gneiss.

This re-heating and melting of rock, already deposited, was most probably due to the fact that the tendency of the cooling process going on in the crust of the earth was to preserve uniform thickness of the crust as nearly as possible. Thus, if half a mile thickness of crust were scalped off an upland, and the materials washed down into an adjoining lowland, the earth's crust measured through at the lowland would be one mile thicker than at the upland. As this cutting and filling proceeded, the heat of the interior would be equalizing matters by melting again the rocks of the lowland and cooling those of the upland. The gneiss rocks thus re-melted would lose their lines of stratification and crystallize into masses of granite rocks when they cooled, or they might be erupted through fissures in the overlying gneiss, and cool into sheets or dykes.

SCHIST.

This is substantially the gneiss after it has been washed down and deposited in new localities and beds. It has had much more trituration than gneiss, and has undergone additional assorting, and is more carefully stratified. It is also somewhat laminated, owing to the fact that the foliated materials, such as mica, etc., are laid down flat, whereas in gneiss they just as often stand on edge as flatwise.

SLATES.

These are the finest of the stratified laminated rocks, the grains being rather more flat than round, and they are always laid down flat, thus giving a laminated structure to the slate. There are three slates among the primary rocks, the bottom one resting on the schists or gneiss being the micaceous slate, the second the talcose slate, and the third the chlorite slates. The whole three, together with the clay shale next spoken of, are the great gold-bearing rocks of the world. The mica slates are blue or gray, specked with minute particles of mica, the talcose and chlorites being greenish, the chlorite being the cleanest and brightest green. The talcose slate is the most auriferous, and feels greasy.

SHALE.

Shale is made up of the finest rounded particles, and contains very few flattened particles. It is, therefore, very slightly laminated, and is nearly always made of clay with some sandy particles. The clay shales of the primaries generally rest on top of the slates

QUARTZITE.

This is the sandstone of the primary formation, and is composed of the silica washed out of such silicated ternary minerals as have decomposed. It is the same as the sandstone of the secondary and later formations, except that it is composed of more perfectly crystalline grains and has fewer impurities mixed with it. A variety called *Itacolumite*, or "elastic sandstone," has the grains and the connecting cement arranged in ball-and-socket fashion, and sometimes with smali grains of mica scattered through it. This gives it a certain flexibility; but as it does not spring back of its own accord, it ought not to be spoken of as elastic. It is the best natural stone for "inwalls" of furnaces, as its peculiar structure prevents expansion or contraction, the open joints taking or giving all the slack either way.

MARBLE.

This stone gives us our first glimpse of the great life-sustaining element, carbon, which element we will further discuss in the chapter on The Coal Measures. Marble is either calcite (carbonate of lime), or magnesite (carbonate of magnesia), or dolomite (carbonate of lime and magnesia), and its method of deposition is described further along under the head of limestone; but these limestones of the primaries are always highly crystallized into the marbles, as the result of heat under pressure and non-access of air, as with the other crystalline rocks of the primary times.

As these primary rocks are the bottom sedimentary rocks, and are mostly overlaid by the secondary and tertiary rocks; we don't know as much about them as we do about some other things. It is a fact that nearly all the mining (other than coal and iron mining) is done among the rocks of this formation, and the experts have accumulated volumes of information regarding the details of these much-twisted rocks; yet as these rocks constitute more than half the thickness of the earth's explored crust, the observations yet made don't reach very far into the mysteries. A serious difficulty is found in the want of any fossil remains of sufficient definiteness to enable us to distinguish the different rock beds, or identify periods of deposition. Fungoid and infusorial life commenced during the later primary times, but did not develop variety.

We have got so far along, however, as to have made four great divisions of primary time, and we call them the Laurentian, the Labradorian, the Montalban and the Huronian. The Laurentian, of about five miles in thickness (from the Labradorian down to the lowest explored point), forms the Laurentian Hills of Canada. These hills are supposed to be the oldest land now known above the sea level, or exposed to the air. They form the watershed between the streams flowing into the Hudson's Bay and those of the St. Lawrence Basin. The Labradorian is found on the eastern end of the Laurention, which dips under, thus leaving the Labradorian rocks all the credit of making up the forbidding and inhospitable coast cliffs of Labrador. The Montalban group makes up the White Mountains of New Hampshire, and is supposed to be of later age than the Labradorian, although the evidence is not complete. The Huronian is the upper group of the primaries, and most of the crystalline rocks of the Atlantic States are members of this group. The gold-bearing slates and the earliest iron ores are found among the Huronians.

Although all four groups of these primaries cannot extend around the globe, yet no borings have yet been carried down through the bottom secondaries without cutting into some primary rock. They form the bed-rock of the American Continent. They are the country-rock of the Pacific Slope west of the Sierra Nevada, and of the Atlantic Slope east of the Blue Ridge. They are covered over in many places on the Pacific Slope by lava and other eruptive rocks in sheets and even mountains, and by tertiary beds of clays, sands, etc., without the intercalation of secondary rocks. On the Atlantic Slope they are obscured in several places by patches of later secondaries, and are covered up, along the immediate sea coasts from New York southward, by great plains of tertiary beds. The first rocky rapids in all the Atlantic rivers are formed by the primary rocks, which at these points dip under the tertiary plains.

The country from the Blue Ridge to the Sierra Nevada is broken up in many places by upheavals of primary rocks. Passing over the Cincinnati rise, as it is called, where the lower Silurian rocks are brought up and the primaries nearly break through, we will instance the Ozark upheaval, which, extending through Missouri and Arkansas into a corner of Indian Territory, furnishes the lead, zinc, silver, iron and granite of those regions. The Lake Superior iron mines are among the primaries, the copper mines being in a great trap range where the igneous rock is forced up through the lower Silurian sandstones. The Black Hills are an upheaval of primary rocks, and there is a corresponding area in Western Texas. The great Rocky Mountains are of primary formation, but have been upheaved since the tertiary times, as they carry areas of well-marked tertiary beds on their backs.

The rocks of the formations, *i. e.*, the sedimentary rocks, grow more and more homogeneous in composition as we leave the early, tumultuous days and approach the long periods of quietude of the later ages of the earth. In the early days the minerals were all scattered promiscuously throughout the various rocks, and they were consequently of very complex constitution. By the slow and quiet operation of ages of weathering and watering, the silica has been dissolved out, separated and re-deposited in piles by itself as sandstone or quartzite; the aluminas and the limes and all the rest of the important minerals have gone through Nature's crushing and grinding mills, and have been separated and assorted according to size and weight by Nature's sluice-ways and other hydraulic processes.

Apart from the mechanical operations of water, there have been vast chemical forces at work to break up the prime minerals so that they could be assorted by hydraulic power, and it must be remembered that decomposition is as much a chemical process as composition. Consider only three prime minerals, feldspar, hornblende and augite. The first contains silica, alumina and an alkali, potash, soda, lime, etc.

Hornblende gives silica iron, alumina or other base, and augite gives silica alumina, lime, magnesia and iron. When the silica has been dissolved out of these and re-deposited as sandstone or quartzite, the other minerals are also released and at liberty to form new partnerships and build new rocks. A very respectable earth crust could be built up out of these three ternaries and the one binary, water.

AQUEOUS ROCKS.

We know very much more about these rocks than we do about the primaries, for we can get at the edges of these all aronnd whole areas. They occur in spots (to be sure the spots are as big as islands and almost as continents sometimes), while the primaries extend all around the globe. They are several miles in thickness, but that don't count, as we can get at the bottom of them and at the top too, and at pretty much any intermediate point, but we know nothing about the bottom of the primaries, and very little, comparatively, about intermediate points. The top surface of the primaries is a surface composed of wrinkled and upturned edges of strata upon which the calm and placid beds of the secondaries are laid down flat, thus showing sharp division lines.

During the long and quiet intervals between the cataclysms, some very important operations are going on, and the features, in minor detail, of the face of the earth are worked into present shape by hydraulic processes. Look at an ordinary hillside covered thickly with stones and small boulders. The inexperienced says to himself that, being so thick on the surface, the stones must be still thicker below, and as they are fragments of pure feldspar, worth four dollars per ton, he digs extensively into the hill and finds the stones very few and far between.

Having bought his experience, he goes into some other business, and occupies his odd moments in marveling greatly about the stones, until some geologist tells him that the stones he found on the surface were once very thinly distributed throughout a mass of clay some hundreds of feet thick which formerly was on top of the present surface, and that the rains have gradually washed out the clay and soil from under the stones, thus lowering the surface to its present level and causing the stones to accumulate more and more thickly on the lowering surface, while the lighter and finer clay was washed down into the valley.

This cutting down process is going on more or less rapidly everywhere above the water level; very slowly on forest lands and on well-kept grass lands and other lands well roofed in by turf or moss, but very rapidly and destructively where the land is cultivated or laid aside as worn out. For example sake, we will cite James River, which in Captain John Smith's time was described as beautifully clear and limpid, but which is now muddy for eleven months a year. The tidewater portions of the valley of this river are rapidly shoaling into meadows overgrown with marsh grass. The soil to make these meadows and muddy this water is washed down from the cleared lands and old broom-sedge fields up the valley, where they rarely fertilize wornout lands and sod them down to grass, but either clear new land or emigrate, and the owners of the rich tidewater meadows use them principally for snipe pastures. New owners will learn to dyke and ditch them some day.

Let us look at another American river, the Mississippi. The engineers who have been taking care of its several mouths have measured over and over again its discharge per year of water and also of solid matter carried in suspension and dropped in the Gulf of Mexico where the river current slackens and stops. This solid matter or silt amounts to enough each year to fill a hole one mile square and two hundred and sixty-eight feet deep. This is a layer one foot deep spread out over two hundred and sixty-eight square miles, or a small county each year, and it would cover the whole State of Pennsylvania one foot deep in one hundred and seventy-five years. The face of the country shows that once the mouth of the Mississippi was above Cairo, and at the head of a long, narrow bay extending down to the Gulf. This bay was about one thousand miles long, and about one hundred miles wide at the mouth, and it has all been filled up and rendered fit for corn, cotton and sugar plantations by the same processes that are now shoaling the estuary of James River. The Mississippi silt has been washed off from the surface of twenty States and Territories covering an expanse of a round million square miles.

The tidal currents of the ocean and the lashings of the surf are continually cutting out sand and silt along the coast lines of the continents and islands, and re-depositing the materials elsewhere, thus forming new beds in new places at the expense of old beds in old places.

All lake and sea bottoms are continually being added to by the dropping of the shells and stems, etc., of infusoria. Under the microscope a drop of water is seen to contain numerous little scraps of vitality called diatoms, spicules, wheels, spores, etc., and each individual scrap has a shell or skeleton or stem made out of matters such as lime and silica held in solution in the water. These shells, etc., are all deposited on the bottom of the lake or sea when the scraps die, and the rivers are all the time washing down more lime, silica, etc., to provide shells for more scraps, and so on. The great limestone beds are all the result of this series of processes, and one kind of limestone, called oolite, is composed of round shells looking like fish eggs, ranging in size from a shad egg to salmon eggs.

When we consider that only one-fourth of the earth's surface is dry land, and that these submarine deposits are going on all the time over the other three-fourths, we can form some idea of the amount of work that is constantly going on. The process of hardening these beds of clay, silt, shells, etc., into solid rocks is simply one of long-continued compression, with occasionally some action similar to the "setting" of mortar or cement.

The absorption of water into the texture of the rocks is going on all the time, too. A familiar example of this is seen in the absorption of water by caustic lime when being slaked, and yet the lime, when not overslaked, appears to be as dry as before. Brown iron ore, called limonite, was formed by the washing down and solution of the red iron ore, after which it was re-deposited with fourteen per cent. of water inclosed in it, and when this ore is roasted the water is driven off, leaving it red ore again.

Water thus absorbed is called water of hydration or of crystallization, and it is estimated that fully one-sixth of all the water belonging to our globe has already been locked up in the rocks by these processes. How much has been locked up by the process of watering railroad and other stocks is not yet estimated.

The secondary rocks are looked at with different degrees of interest by different people. Owing to the continuing hydraulic assorting processes of Nature, the composition of the different rock beds grew simpler as time advanced, while the more peaceful condition of things permitted the varieties of life to multiply enormously. The gold and silver miner has little use for level banks and beds of rocks full of fossils, while the mining speculator has still less use for fossils in banks, as they won't lend money on his stocks. The coal and iron miner feels at home among the level homogeneous banks, while the biologist blesses the fossils, and works lovingly among them in search of the missing link. We will, therefore, describe these rocks and refer the reader to the Geological Column.

SANDSTONE.

This is derived from the primary quartzite which has been washed down and deposited in new beds during secondary times, and became hardened by time and pressure. The sandstones are found in beds all the way up at intervals throughout the whole secondary series, and the sands constitute at least three-fourths of all the mass of materials in this formation. The principal differences to be seen among the beds are variations in size of grain. There are four great plates ot sandstone between the top of the primaries and the bottom of the great coal measures. The Potsdam sandstone lies on the primaries and forms the crest and western slope of the Blue Ridge. The Medina sandstone is the second, and forms the crest and western slope of North Mountain. The Oriskany is the third great sandstone, and forms the crest and western slope of Capon Mountain and others on that line of upheaval. The millstone grit is the fourth great sandstone, and forms the base of the coal measures. The Mahoning sandstone is the plate that divides the coal measures into upper and lower coals.

These great sandstone plates give the topography to the country they traverse, as they are the hardest rocks and wash down the least, while the softer limestones. slates and shales, in between them, wash out rapidly, and thus form valleys, leaving the sandstones to cap the ridges and protect them against too rapid denudation.

This region west of the Blue Ridge is a magnificent illustration of the action of upheaval as shown in Nature's grand and original performance of upheaving the Blue Ridge and the primary region east of it. She drove it up like a wedge from below, and she has squeezed up into great mountain wrinkles all the country between the Blue Ridge and the Allegheny Mountains. It is estimated that if the seventy to eighty miles of mountain and valley between those two ridges were flattened down into level plain, they would cover at least one hundred and twenty miles The wrinkling has been so powerful that in many places the sedimentary beds stand on edge, and indeed at times they lean backwards.

LIMESTONE.

This is simply the re-deposited debris of the marbles of the primary formation, supplemented by the work of marine animals and vegetables of the secondary ages. It is probable that those beds in which the most fossils are found are the ones formed by the slow building of the infusoria during secondary times, while those of larger grain and fewer fossils may have been made of materials derived from washing down the primary marbles. This latter material is most apt to be deposited near the shore line of the ancient seas and to have sand and clays mixed with it; while the limestone of the secondary age would be formed in deep, still water, and would thus be of finest grain unmixed with anything but fossils.

CHALK.

This is given a subdivision all to itself, as it characterizes and gives name to a whole group of secondary beds, viz.: the Cretaceous, which is the upper group of the secondaries. The earlier limestones had time and pressure enough to pack them down and harden them, but these chalks, which are substantially the same materials, have not yet had the advantages of the older rocks. The sounding apparatus of recent exploring vessels have brought up from the deepest sea bottoms yet found quantities of semi-fluid chalk, showing that the infusoria in the sea water of to-day conform to the habits of their ancestors in the matter of sepulture.

COAL.

This, although the least in quantity of all the secondary rocks, except fire-clay, is very much the greatest in importance among the secondary or any other rocks, but as it will be treated more fully in its place in the chapter on The Coal Measures, it will be passed over here, with the recommendation that the reader study its position in the Geological Column.

SLATE AND SHALE.

The slates and shales of the secondaries are of the same construction as those described among the primaries, but they differ in condition, those of the primaries having been severely cooked by the early heat and slightly crystallized; while those of the secondaries have not been under fire, and are only compacted by long pressure. In the anthracite coal regions, however, the slates and shales have been slightly heated, at the same time the hydrogen was being driven out of the coal.

The secondary rocks form the country rock of the Mississippi basin, and they are also found in areas east of the Blue Ridge of the Appalachian Mountain range. The eastern edge of the Potsdam sandstone caps the Blue Ridge from near Harrisburg down past Harper's Ferry and on through Virginia and the Carolinas, thence past Cartersville, in Georgia, to the Coosa River, in Alabama, near the Selma and Rome Railroad bridge. In West North Carolina and Southern Virginia this stone has been terribly tossed up and broken through by the upheavals of the primaries, but it gets control again and passes under the valley of East Tennessee.

The secondary rocks extend westward beyond the Mississippi to the Rocky Mountains, broken, of course, where the before-named primary upheavals come up through, but the further west they extend the thinner they get. Rock beds which are hundreds of feet thick in the Appalachian Mountains are represented in Missouri by feather-edged beds of but few feet in thickness, while at the foot of the Rockies many of the beds are missing altogether.

There are detached areas of secondary rocks east of the Blue Ridge, which, although small, are of great value, for these areas furnish all the brownstone used in building in New York and other cities in the Eastern States. The stone comes from the Triassic beds of the secondaries, which are found in troughs in the primary rocks, all the way from Nova Scotia down to Georgia, the beds, however, not being continuous. The northern slope of Nova Scotia is of this Triassic age. Shaler's quarries, in Connecticut, furnish nearly all of this stone used in Boston, Providence, New York, New Haven and Hartford. The red soils of New Jersey are underlaid with it. Parts of the Susquehanna, near York, and all the Monocacy valley are of this formation. The Grant-Seneca quarries are in this, and the Virginia Midland Railroad runs across many miles of it.

The gray sandstones in which the Richmond coals are found are of this age. The Deep River and Dan River coals of North Carolina are in these rocks, and this writer thinks he has identified them in South Carolina and in Georgia at several points.

TERTIARIES.

These beds are rarely hard enough to be called rocks. They cover great areas of country in the basins between the Rocky Mountains and the Sierra Nevadas, and also along the Pacific coast where they have eruptive rocks above or below them and all through them. In many places they have been so burnt by heat from eruptive rocks that they are often mistaken for older rocks. The "Bad Lands" of the Upper Missouri River country are of tertiary formation, and they appear to have been used as cemeteries by the tertiary animals of that region, for they are packed full of skeletons, and have furnished more links in the chain of evolution than all the rest of the world yet known.

On the Atlantic side the coast lands are all tertiary, from the Hudson River around to the Rio Grande, and they extend inwards up to the line of the "Sand Hills," which line marks the boundary of the ancient coast, the "Hills" being the ancient sand dunes blown up by the winds, just as they are in Southern France and many other coasts, to-day. The fact that this line of sand dunes coincides for many hundred miles with the line of the first rocky rapids in the rivers, is corroborative evidence. Wherever there are sand dunes they are always on the line of the rapids in the Southern States. Many portions of this great tertiary plain, between the sand dunes and the sea, are covered by swamps and drift clays and by river washings, such as the great Mississippi bottom-land country, all of which are quaternary.

Clay.

The clay of the tertiaries differs in no very important respect from the clays of other formations, and will be referred to again among industrial minerals.

Sand.

The sands of the tertiaries are generally finer and purer than those of earlier deposition, as they have undergone more washing and assorting, and are therefore better fitted for man's use in the building arts and for making glass. There are some half-hardened sandstones among these beds which are composed of fine, clean, sharp-pointed sand, which crumbles easily under the fingers, and in which the beds contain grains of uniform size, which are especially useful.

Gravel.

The gravels of the tertiaries are the same as other gravels, but they are in such great quantity that they are a very prominent feature, and are used for ballasting railroads, surfacing turnpike roads, and many other purposes. A large, well-located gravel pit is a valuable piece of property.

Marl.

This is the lime rock of the tertiary formation, and is to this formation what chalk is to the upper secondary, limestone to the lower secondary, and marble to the primaries. It is soft yet, but if we pile a few miles of new rocks on top of it, and wait say a few million of years, it will guarantee any required degree of hardness. It is the work of those tireless infusoria, who go on locking up carbon, without asking themselves when there will be no more unappropriated carbon to lock up. There are marls which contain phosphoric acid combined with lime, and these are great marls for fertilizing purposes. They are generally granular in texture and greenish in color, and are therefore called "Green Sand Marls.' The phosphoric acid or phosphate of lime is supposed to come from the great deposits of bones and fish remains found in and about these marls. There are other green marls which contain iron sulphate, and as these sour the land the amateur fertilizing farmer had better look sharp. The writer has known, however, of several cases in the Patuxent regions of Maryland, in which this sour marl was spread and killed everything, but in the third year magnificent crops were produced, and there have been four successive crops since, all good ones too, from which it would seem that exposure to the weather decomposed the iron sulphate and released the sulphuric acid, which in turn attacked the lime and formed plaster.

QUATERNARIES.

These beds are the most recently formed, and they are still being formed over the three-fourths of the earth's crust which is under water. The sands and gravels and marls of this formation and the ordinary clays, too, are substantially the same as those of the tertiaries, and need no special mention, but there is a clay called

Drift Clay

Or boulder clay. It is an irregular and unstratified mass of miscellaneous materials, mostly yellow clay, with boulders and other rounded fragments scattered all through it. It is supposed to be deposits of pulverized rocks and formations which were ground off by the ice during the last *Glacial* period. There are portions of this continent which are covered for hundreds of square miles by deposits of these clays. Many rivers emptying into the St. Lawrence and the Great Lakes cut through great hills of drift. The Ontonagon River running into Lake Superior is a fine example of this, as it runs for many miles between banks, often a hundred feet high, composed entirely of drift clay and boulders.

One theory advanced to account for the presence of this clay and boulders is that the orbit of the earth around the sun being elliptical and constantly changing, it may have become so elongated as to get out of center with the sun, and thus produce shortening of exposure of northern hemisphere each year to the sun's heat. This would cause an accumulation of ice over the northern half of the globe, which ice would expand and grow southwardly, carrying with it the stones frozen into its mass. These stones would do just as in modern icebergs and glaciers, and thus cut out grooves and striæ on the surfaces of the rocks they passed over. As the orbital distortion corrected itself the heat came back, the ice melted and dropped the boulders, the floods of water from the melting ice scoured out all the clays, etc., from earlier formations and re-deposited them in great unstratified hills of unassorted clay, and things got straight again.

All the hills and mountains south of Hudson's Bay, down to Pennsylvania and east of the Mississippi River, except Mt. Washington, show the grooves on their very tops, showing that the ice went clear over them. Mt. Washington only shows them cut deeply on her sides, nearly up to the top.

Another suggested cause for this change of climate is that as the earth staggers on its axis (like a humming top asleep), making a complete stagger and recovery once in about twenty-five thousand years, it would thus incline its North Pole away from the Sun for long intervals. This theory can be called rather diaphanous, as the exposure and non-exposure would seem to be about equal under the proposed arrangement.

The most probable theory advanced is that the changes in the cooling Sun were accompanied by the evolution of a hazy gaseous envelope which shut off temporarily some of the Sun's heat, and produced the glacial effects, and that this hazy gas was afterwards re-absorbed or combined with something else so as to become clear again.

Soil.

Soil is the top covering of that portion of the earth that is above water. This is a general statement, but there are of course particular spots where the soil of uplands has been scraped off, which we will not allow to count this time. Soil is the result of comminution and decomposition of minerals combined with decomposition of vegetable and animal matter. Soils are also further enriched and comminuted by passing through the bodies of earth-worms, and this to a much greater extent than had been thought possible previous to Darwin's book calling attention to it.

In the spring of 1882 the writer observed a path across a common at the village of Avalon, near Baltimore. The common was covered with grass kept short by the village cows, and the path was so dotted with worm casts that he cut a pasteboard one foot square and failed to put it down on the path anywhere without touching a worm cast. He searched for an hour over the rest of the common and found the grass sod was dotted the same way. A rain spread the casts over the ground, and in twenty-four hours they were renewed just as plentifully. Six times in one month was this repeated. It is within bounds to state that if this rate of deposit is kept up for three months in each year, for fifty years, it would add one inch of soil to the the surface of that common.

FOSSIL EARMARKS.

Now that we have got up to the top of the earth's crust, we will study the remains of the organized life that has been growing more complex all the time that we have been assorting the rocks into more simple varieties. The general characters of the fossil remains change with the ages, which correspond to whole groups of rocks, not with single beds. In other words, the fossils correspond to the ages, not the characters, of rocks, and the rocks are arbitrarily grouped by man to correspond to the changes of the fossils. This is because the life was substantially the same at any one time, whereas the rocks being laid down in that same age, and in which the remains of the life were being deposited, were here of limestone and there of coal, and again of sandstone, and so on.

There are some sixty odd thousand species of fossil remains now known and described by the palæontologists, but the size of this volume will not let us speak of more than the general groups into which they are divided, and which give names to the ages. Each age thus named is the period during which that type of life attained its greatest development. It can, in general, be said that the life thus distinctive of any age had its beginning in the age preceding, and that it declined in the age next succeeding that of its greatest development. Types of life have declined, but have never perished, although many species have disappeared. The ages of life are as follows:

AGE OF FUNGI.

This was the Eozoic Age, or Dawn of Life, and happened along during the later primaries. The occurrence of marbles among the primaries shows that there must have been some sort of low vegetable growth to secrete carbon out of the air and transmit it to the water where it was taken up by the infusoria and used for shells, etc. Possibly some form of seaweed floating around was the first life, and almost microscopic in size. The rocks of the primary series have been so transformed by heat that well-defined fossils are burnt out, although Eozoon is being found increasingly.

AGE OF MOLLUSKS.

These chaps were shell-fish, creatures that have their bones on the outside of them, where they do duty as skeletons, and as houses, and as armor. Our modern crabs, oysters and others of that ilk are remaining species of this type. There were big snails and sea conchs and worms covered with jointed armor made of rings of shell. These shell-fish held possession of affairs on this world all through the Silurian age.

AGE OF FISHES.

This was the age of the fish who lived on the infusoria, and on each other, and on shell-fish, which they cracked up just as our sturgeon do to this day. Many of them had the floors and roofs of their mouths paved with flat-headed teeth set as closely as the hob-nails on a miner's boot sole, all properly arranged for crunching oysters, etc.

AGE OF COAL PLANTS.

This age followed the fish, and appears to have been a time of peace and plenty, when vegetation of enormous vigor grew luxuriantly, died properly, and carried down into the ground with it great quantities of carbon. The carbon stayed there and mineralized until man came along and found it would burn. He called it coal, dug it out, organized companies, swindled widows, melted iron and made war with it. Great civilizer.

AGE OF REPTILES

Reptiles include lizards, crocodiles, alligators, turtles, frogs, toads, terrapins, sea serpents and see snakes. These interesting creatures were on top all through the Triassic, Jurassic and Cretaceous periods, and had a long lease of power. There were lizards, called Saurians, fifty feet long and bigger round than a sugar hogshead. Their legislatures invented Reptile Funds.

AGE OF MAMMALS.

These are the creatures that suckle their young,—bats in the air, whales in the sea, elephants and others on land. They appear to have got a start in the top of the secondaries, to have increased beyond all reason in the tertiaries, as regards quantity, but their choicest specimens were produced about the end of the tertiary and beginning of the quaternary. Some most preposterous creatures were gotten up, but their preposterosity consisted chiefly in their great size. It would take about two-and-a-half of Barnum's Jumbo to make one boss mammoth. They had an elk in Ireland which would cut up into a whole family of our best bull moose. The great cave bear would whip a four-in-hand team of California grizzlies. The British Lion of those days was a tiger who had incisor teeth eight inches long, and the American Eagle was a lion built on the same magnificent scale. The lions and tigers of the present day are mere kittens in comparison.

But the boss mammalian was still to come. He makes a little drove all by himself, and some writers have gone to the length of giving him a whole age to himself, the "Age of Man." We cannot consent to this, for good reasons. One is that he is only a mammal, after all, and has not yet sufficiently differentiated himself from his relatives to justify such a distinction; another is that this differentiation is still going on and man has not yet reached his culmination. If we are on hand when his high level has been traversed and he strikes the down grade we will revise this chapter and allot him the necessary space.

The regular order of things provides that the life type shall originate in one age, culminate in the next age, and begin to decline in the next. Man has only been here a short time, and he is still in the age of his origin. His culmination will come in the next age, and his decline in the next. What will be the type of life that will succeed him on this globe? There is already more *essential* difference between an American or English naturalist and a native of Terra del Fuego or Central Australia than there is between the latter and the gorilla and chimpanzee.

VEINS AND DEPOSITS.

Let us consider that a portion of the earth's crust has been humped up in a long ridge. Now a cross section of the ridge would show the rock strata arched upwards across the crown of the ridge and arched downwards across the foot slopes of the hill, where the strata curve back again to their former level. If the upheaval was sufficiently powerful, the rock strata would be cracked across into wedge-shaped fissures through the crowns of all the arches, but the fissures in the up-bent arch would have the wedge butt upwards, and the down-bent arches would show the wedges with their butts turned downwards. Now let us suppose these fissures to have been filled with melted rock which had cooled and probably coarsely crystallized, and we will call these intruded masses of eruptive rock, dykes.

Again, it may be that the eruptive rock has not had pressure enough to wholly or even partially fill the fissures, and that they have been open for ages but gradually choking up by deposits crystallizing on the walls, formed by the passage of mineral vapors or mineral waters. These deposits would form in layers or crusts, one on top of another, and of various compositions, as the heat or force varied. In course of time the fissures would narrow and finally choke up, and the whole affair would then be called a vein. The walls of the fissures would be irregular, which would give rise to chimneys or openings, through which the mineral vapors or waters would rush faster after the narrower portions were choked up, and thus give rise to more sameness of constitution at these points.

Again, the fissures might be filled by the percolation of mineralized water through the wall rocks, or by water from the surface which would deposit its minerals on the walls, and the fall of portions of the wall rocks or the washing in of surface trash helps to fill up the fissure with materials that are not needed by miners.

Sometimes the fissures are mere surface cracks formed by the cooling down and shrinkage of hot rocks, which are analagous to the shrinkage cracks formed in mud deposits left high and dry by the subsidence of a freshet. These cracks get filled up by deposits of mineral matters crystallized or precipitated out of impregnated waters, which may find their way in from above or below; or may concentrate in the cracks by exudation from the sides of the cooling rocks.

When this class of vein is small and cuts through the rocks in many directions it is called a ribbon vein, and fine examples of it are often seen in blue limestone cut in all directions by criss-cross veins of white calcite. When these veins are large they are called segregated or lenticular veins, and they are the principal gold-bearing free-quartz veins, but they do no carry very much sulphide ore

These lenticular veins are found sometimes several miles in length, forty or more feet wide at the middle and running to a point at each end, giving them the ground-plan shape of a lenticle. This shape is all right for ground plan, but it is very objectionable when applied to the cross section, for then the vein runs down to a feather edge and "peters out" in depth as well as length.

Whether these segregated or lenticular veins are really formed by the shrinkage of cooling rocks, or whether they are the wedge-shaped fissures of the up-bent arches before mentioned, is an open question, and in such cases it is well to assume that possibly both causes had a hand in the effect. It is, however, a fact that very often heavy granite or trap dykes are found paralleling these lenticular veins on either side and this would support the view of the lenticles being the fissures at the crown of an arch, while the dykes were the fissures in the down-turned arches of the foot-hills. We could very easily determine this if it were not for the fact that Mother Nature very often so scoops out a hill as to make a hollow of it, and fills up old hollows to look like hills.

It is to be observed that while the lenticular veins peter out in depth, just as wedge-shaped fissures, point downward, ought to do, the dykes widen out in depth just as wedge-shaped fissures, point upward, ought to do; and this brings us to the point that these heavy dykes, widening downward, are generally the fissures which contain the sulphide ores in greatest strength and variety. The dykes become veins when the contents of the fissures change from barren, eruptive rock, to vein stone and mineral. These are the big mines of silver, copper, lead, zinc and iron sulphide ores, and what gold they contain is mixed with the sulphides of other metals and came up with them from below. The gold that is in the quartz-filled lenticular veins most likely came in from above after having been released from sulphurous company by decomposition of sulphide ores out of the other fissures

There is a very peculiar class of mineral deposit among the silver districts of our Western Territories which appears to be the passage or connection of a fissure with a cavern in limestone, and the subsequent filling of both fissure and cavern with sulphide ores. Sometimes the fissure is a mere ribbon as to size, but the cavern contains millions of dollars worth of ore. Such an affair was the Little Emma mine—of great productiveness, but rascally reputation. A little stringlet of ore was all that led the proprietor to the right place.

The ore deposit called a gash vein is really nothing but a flattened cavern in one kind or bed of rock, generally limestone. The flatness can be either vertical, horizontal or diagonal when referred to the stratification of the rock. Sometimes these veins will be found with apparently no communication by means of strings of ore, but close observation will generally detect some open joint or other fissure through which the ore was charged in.

There is also a deposit called a contact vein, which is generally found between a bed of eruptive rock above, and a bed of sedimentary rock below. This is the approved form of vein at Leadville, where the carbonates of lead and iron containing silver chlorites rest on limestone and are covered by an overflow of porphyry. Very many theories are now under discussion about the methods of the deposition of these ores, but pending the decision of the problem "how it got in," the practical Leadvillians are rapidly showing the world all about "how to get it out," and how to sell stocks on it after it has disappeared. These contact veins, having no side walls like fissure veins, admit of twisting and turning the drifts underground towards all points, and thereby the miner takes out nine-tenths of all the ore. The other one-tenth is left standing in the walls of the drifts, and is used to convince innocent investors that the blocks of rock between the drifts are solid ore. The result is that the empty mine often sells for more than the full mine was worth.

The courts of Colorado are now ruling that these contact veins are not really "veins," as they do not cut through the stratifications, and that they are really beds between other beds The miners are also beginning to call them by a new name, viz.: blanket lodes.

Concerning the question of the increase or decrease of mineralization of veins as depth is attained, there is an absolute certainty that the tendency is properly towards increasing with depth, as the whole earth weighs up to a specific gravity of 5.2, according to the astronomers, whereas the rocky crust averages only half of that. This means that the core of the globe is composed of very much heavier materials than the crust, and the metals are the only substances known which are heavier than the rocks.

No mining yet done by man has gone deep enough to get below the influence of local causes, due to movements of the earth's crust, so as to reach down into this metalliferous globe core, and it may be that some millions of years must elapse before the globe cools down sufficiently to permit of it. The increasing heat of the rocks, due to the depth, and the heat arising from oxidation of vein rock, due to the access of air, have rendered it almost impossible to carry the Comstock workings any deeper.

It would seem that the class of veins most likely to lead into this metalliferous earth core would be those which have the point of the wedge upwards and which widen downwards. In a district which has undergone no very great amount of denudation or scouring since the ridges were upheaved, these veins will be found among the foot-hills, or along the lower portion of the sides of the ridges, and striking parallel to the ridges, and they are more likely to carry a preponderance of silver than of gold. The "blow-out" veins on top of the ridges generally carry more gold than silver, and get narrower as they get deeper, and they also get richer with depth, principally through the concentration of the same amount of metal in a smaller amount of vein stone. There is also the additional reason, that the metals being heavier than the vein stone they would avail of every disturbance to shake themselves down a little further every time, whether the vein stone happened to be in liquid, molten or solid condition.

When we reflect upon the fact that any injection of liquid or vapor from below towards the surface, accompanied by an upheaval of a ridge and the fissuring of the upturned and downturned rock arches, would be simply the action of a gigantic "squirt," we will see reasons why the squirted substance, cut off by the closing of the fissure bottoms under the crown of the centre arch, should break a passage through to the side fissures or come through to the surface at new points further up the ridge slopes. This action would account for the presence of bodies of valuable mineral in the country rock entirely outside of the rock walls of the regular fissures, and the breaking down of masses of wall rock. Some of the greatest "Bonanzas" of modern times are found thus situated out in the country rock beyond the vein walls.

II.

THE COAL MEASURES.

Carbon—Bituminous Coal, Anthracite, Cannel, Splint or Block, Lignite, Peat, Coke. Position—False Coals, Lower Coals, Upper Coals, Triassic Coals, Tertiary Coals.

CARBON.

This, the great heat and life-sustaining element, appears to have been one of the latest of the overhead gases in getting down to the crust of the earth. The old conundrum, as to whether the chicken preceded the egg or the egg the chicken, is paralled in modern times by the analogous one of whether carbon preceded life or life preceded carbon on this world. Certain it is that wherever we find life or the remains of life we also find carbon, and wherever we find carbon we find life or its remains.

There is a small percentage of carbonic acid still remaining in the air. Vegetation is continually absorbing it, and a portion of it is being continually breathed back again into the air by animals who live on vegetables, or on other animals who live on vegetables. Another portion gets back into the air by the death and decomposition of animals and vegetables, but a large portion gets permanently locked up in the tissues of the earth's crust by being mineralized into coal, and by being turned into limestone by the insects and infusoria, as mentioned in the chapter on Bed Rocks.

Within recent centuries, man has begun to assist his Mother Nature in this process of returning carbon to the air by burning coal and limestone in increasing quantities, and thereby prolonging his lease of life on this planet.

The crystalline marbles of the primary formations contain the earliest known carbon, and the graphite of the same formations came next. After the great and good substance once reached the earth's surface, it continued to come down in increasing quantities up to the beginning of the Carboniferous age. Then its rate of descent remained about stationary throughout that age, and has decreased ever since, until now we have not much more left to come and go upon.

It is thought that at the setting in of the Carboniferous ages the regions now constituting the coal fields were great level swamps pretty much filled up with the sands and silts of the previous rather quiet Devonian times. These swamps were covered with a luxuriant growth of peat moss, urged into extraordinary rapidity of growth by a great quantity of carbonic acid in the air of those days. A few thousand years of such growth, and then a slight subsidence of the land, and a period of submergence during which the waters laid down a series of sands and silts in layers, and then an uprising of the land again, appears to have been the order of the procession. This, repeated many times, and then the lapse of some millions of years, in order to give time for the peat to mineralize into coal, and the sands and silts to harden into slates, shales and clays, would produce exactly what we now find in all our great coal fields.

We should expect that coals produced in this way would vary in composition fully as much as other rocks. The peat bogs are liable at any time to have slight overflows from local freshets, and these will deposit layers of sand or silt in some spots and not in others. These will be found in the coal as streaks of shale or slate which thin out and disappear further on. Sometimes the sand or other trash will be mixed in with the peat moss, and this results in sandy coal.

Then again, more hydrogen will be locked up in the coal in one moss than another. One portion may be afterwards better covered up by hills of new rocks than others, or an intrusion of melted rock or upheaval of mountains may burn out some of the hydrogen or other constituents, and thus make anthracite or natural coke in portions of the coal field.

The normal coal appears to be about what is called bituminous coal, and is best represented by the coal of the great Pittsburgh bed; all other coals appearing to be either incomplete or else complete coal altered by heat.

BITUMINOUS COAL.

This is the great coal of the world, and well it deserves its place, for it contains everything that goes to make up coal, and can be altered by man so as to suit any of his special purposes. A descriptive list of its best variety is about as follows:

Gravity	1.1 to 1.3	Oxygen	5 p. ct.
Hardness	1.0 to 1.5	Water	3 p. ct.
Carbon	85 p. ct.	Ash	2 p. ct.
Hydrogen	5 p. ct.		

Lustre, sub-vitreous; clearness, opaque; color, black; feel, smooth to harsh; elasticity, brittle; cleavage, seemingly great but really slight, as its square breakage is owing not to crystallization, but to jointed structure; fracture, even; texture, granular, cubic.

Very often there is an iridescence on the surfaces of blocks, and the coal is then called "peacock coal." This is the composition of normal coal, but hardly any two beds contain coal of exactly similar constitution. The differences, however, among the coals of any one age and locality are not very large, and are generally only just enough to make one bed give the best gas coal, another the best coking coal, another the best blacksmithing coal, and another the best steam coal, and so on.

An important feature in these coals is their power of resisting slaking by exposure to the weather. Coals that will slake, or that will crumble when handled, must be used where mined, and are, therefore, least valuable

ANTHRACITE.

This is bituminous coal which has been metamorphosed by heat and pressure, which have burned out some of its hydrogen and compacted it. Its descriptive list is as follows:

Gravity	1.5 to 1.8	Oxygen	1.5 p. ct.
Hardness	2.3 to 2.6	Water	2.0 p. ct.
Carbon	93.0 p. ct.	Ash	2.0 p. ct.
Hydrogen	1.5 p. ct.		

Lustre, resinous; clearness, opaque; color, black; feel, smooth; elasticity, brittle; cleavage, none; fracture, even to conchoidal; texture, massive.

This coal will not burn into coke, because it is already a natural coke compressed from a porous structure into massive texture. The ash that is left after burning anthracite is white or red, the white being normal, and the red results from the presence of iron oxide. Sulphur occurs in all coals, but least of all in anthracite, the heat that anthracited the coal having burnt out most of the sulphur.

All the beds of both the upper and lower coals are anthracited in Eastern Pennsylvania, where there is the greatest assemblage of coal beds known, although unfortunately the total area of the three anthracite coal fields is only about five hundred square miles. There is a field of this coal in Rhode Island, but its position among the upper and lower coals is not determined. It is so hard and useless that geologists think it will be the last thing to be burned up when the final conflagration comes. There are also beds of sub-conglomerate coals in Arkansas, and of lignite coals in the Rocky Mountains, which have been anthracited by the heat evolved during the upheaval of the Ozarks and the Rockies, and there are a great many places where the false coals have been metamorphosed, more or less.

Anthracite is so hard and so free from expansion and contraction under heat changes that it is much in favor as a fuel for blast furnaces, but for puddling and other reverberatory furnaces it does not give flame enough. The invention of the regenerative gas furnace, however, enables it to be used by dosing it once with oxygen in the producer, turning it into carbonic oxide, and then dosing it again in the combustion chamber, thus obtaining all sorts of a flame.

The use of anthracite for household purposes is rapidly extending in Chicago and other western cities, not only owing to its superior cleanliness and freedom from smoke, but also because of the exertions of the trunk line railroads and other shippers. These have, until lately, been sending grain to the eastward with no compensating west-bound freight to fill their cars and vessels. Now they are offering low freights to the coal men, and the increase of this traffic enables them to cut down their grain rates and thus relieve the mind of the granger. On the same principle, ships which formerly paid for ballast now get paid for bringing coal and iron ore from Europe to America as ballast.

CANNEL.

This coal is a variety of the bituminous coal, but differs enough to require a separate place and descriptive list:

Gravity	1.0 to 1.2	Oxygen	8 p. ct.
Hardness	1.5 to 2.0	Water	3 p. ct.
Carbon	82 p. ct.	Ash	2 p. ct.
Hydrogen	5 p. ct.		

Lustre, dull resinous; clearness, opaque; color, black; feel, smooth to greasy; elasticity, brittle to sectile; cleavage, imperfect; fracture, conchoidal; texture, massive.

This coal is never found in a bed entirely by itself, there being always an inch or two of laminated bituminous coal interstratified. In many places a seam of coal will be half cannel and half bituminous.

Cannel coal chips will take fire and burn easily like candles or pitch pine. This is owing to the presence of a large percentage of mineral oil. Even now, since petroleum has sold down below sixty cents per barrel, the men who make refined mineral oil by distillation from cannel coal, in Kentucky and West Virginia, are not broken up, nor do they seem to be losing any extra amount of sleep. Paraffine is one of their chief products, and very fine lubricating oils also.

Cannel coal brings fancy prices in New York for use in open grate library fires, and there certainly is a sort of family resemblance between slippers, smoking caps, Turkish pipes and library fires of cannel coal at ten dollars per ton.

SPLINT OR BLOCK.

This is a very valuable member of the bituminous coal group, and its description is this:

Gravity	1.0 to 1.4	Oxygen	7 p. ct.
Hardness	1.3 to 1.7	Water	2 p. ct.
Carbon	84 p. ct.	Ash	2 p. ct.
Hydrogen	5 p. ct.		

Lustre, resinous and dull vitreous alternately; clearness, opaque; color, black; feel, harsh; elasticity, brittle; cleavage, imperfect; fracture, uneven; texture, foliated.

This coal is made up of alternate leaves of ordinary bituminous coal and cannel coal, and its great value consists in its freedom from expansion and contraction under heat-changes. It is thus enabled to hold up the "burden" in smelting furnaces, and it does not swell up and cake, and thus choke off the passage of the air blast. Why these qualities should result from a mixture of two coals, both of which do swell up more or less, is not clearly determined, but the fact that block coal is frequently found to contain more oxygen than the above table states may have something to do with it. It is also possible that the different layers may behave differently at similar heat degrees and thus counteract each other.

It is to be observed that the coals of the eastern edge of the Illinois and Indiana coal field and those of the western edge of the Appalachian coal field are the block coals, and the presence of the great "Cincinnati rise" between them may influence them.

LIGNITE.

This is the connecting link between the two full-grown coals and the yet growing peats of the present day. It is a very important substance to all the western half of our country, and, therefore, we give below the descriptive list of good average Rocky Mountain lignite:

Gravity...............1.0 to 1.2	Oxygen................18 p. ct.
Hardness.............0.8 to 1.2	Water................. 9 p. ct.
Carbon............... 66 p. ct.	Ash.................... 3 p. ct
Hydrogen............. 4 p. ct.	

Lustre, resinous to dull; clearness, opaque; color, black to brown; feel, smooth to harsh; elasticity, brittle; cleavage, imperfect; fracture, even to uneven; texture, massive to lamellar.

There are two distinct textures to lignite, and they are the same as the two which mark cannel coal and bituminous; one is apt to break up into plates or little cubes, while the other is massive, and fractures in conchoidal surfaces. The two textures in lignite are also found sometimes alternated, just as in the splint coals of full growth. To complete the analogy, the lignites in many places in the Rocky Mountain region are anthracited as completely as are the lower coals in the Pennsylvania districts.

There are spots on this globe where a peat bog is peat on top and good lignite on bottom, and thus lignite is the coal of the quaternary as well as the tertiary formations. It will be again mentioned under the heading of Tertiary Coal.

PEAT.

Although peat is not coal, yet, as it is the carbon basis from which all coal is derived, we will give some of its points, as follows:

Gravity...............1.0 to 1.2	Oxygen ....30 p. ct.
Hardness.............0.5 to 1.0	Water.................30 p. ct.
Carbon,............... 30 p. ct.	Ash.................... 4 p. ct.
Hydrogen............ 6 p. ct.	

Lustre, dull; clearness, opaque; color, grayish brown to black; feel, smooth; elasticity, brittle to sectile; fracture, uneven to conchoidal; texture, earthy to massive.

In a peat bog ten feet deep the moss on the top will be still growing, while the peat at the bottom can be carved into a jet-like pipe, polished highly, and can be used for smoking fine tobacco without injury to the flavor thereof, as the writer knows by experience.

Mountain tops are curious places to find peat, but there are mountains in Georgia and the Carolinas whose tops are covered with peat moss, into which horses sink knee deep. The writer has seen peat crawling up a dry and sandy hill-side, from a footing in a little stream at the bottom. Whether it supplies itself by capillary attraction from the bottom, or whether it simply stores up the falling rain by shading the sand as it reaches upward, was not apparent, but most probably both methods were employed.

In most peat bogs the fibrous structure of the moss is nearly obliterated at a depth of two feet below the surface, the materials being mineralized.

COKE.

This is the carbon that is left after burning off all the other substances, which of course take off some of the carbon with them; so that coke does not weigh so much as the carbon percentage of the coal it came from would indicate. Coke varies so much in physical features that we cannot construct a proper descriptive list for it.

Coals that produce good coke are scientifically called caking coals, because the volatile gases in them swell up and cake together, and gradually oxidize and disappear by distillation, leaving such carbon behind as escaped combustion.

Good caking coals are found in all the beds, from lignite down to the bottom; and the only sure way to test them is to try the experiment of coking them both in oven and in open air heaps, as some coals will coke under circumstances which will burn others completely away.

Coking coal of the very first class is about as valuable property as an unsatisfied mortal can get hold of. Look at the coke of the Connellsville region of West Pennsylvania! The coal is the great Pittsburgh bed, and it is so valuable for coke that they cannot afford to waste it on gas, although, properly handled, it is the best gas coal in the country. That coke is now shipped to Arizona by rail, where it sells for eighty dollars per ton, and yet it pays the silver miners to use it in their furnaces. It is also the principal smelting fuel for the Lake Superior iron ores, at Chicago, Cleveland and other convenient meeting points. Coke from Western Pennsylvania is also coming eastward in rapidly increasing quantities to mix with anthracite in smelting iron. It makes a more open-grained iron than anthracite alone, and this is considered a valuable feature by the makers of Bessemer steel.

There is a very fair quality of natural coke near Richmond, Virginia, which is produced by the intrusion of a hot granite dyke through a bed of triassic coal.

POSITIONS.

Our good Mother Nature indulged herself in five serious spells of coal-making while building the masonry of this continent. These spells came on during the sub-carboniferous, the lower carboniferous, the upper carboniferous, the triassic and the tertiary ages, and she is still at work making peat in this the quaternary age. Before these serious attacks came on she had tried her hand in making graphite beds and black bituminous shales, but the false coals of the sub-carboniferous period were evidently what reassured her and encouraged her to believe that she really could make good coal if she kept on trying. She kept on and succeeded, and we will now inspect her work.

FALSE COALS.

These coals are in among the bottom ledges of the carboniferous rocks, and a good deal of valuable carbon was wasted in making them. They are several thousand feet vertically below the great millstone grit or conglomerate rock, and they are underlaid by the red shales and sandstones of the upper Devonian. These can best be identified by going eastward to the Oriskany sandstone, which is the third great plate of sandstone above the primary crystalline rocks, and is remarkable for being disfigured by pebbles of iron ore which stain its coarse and gritty surface.

Starting from this rock, which is found nearly always on top of a ridge, and going west, the red sandstone and shale, just below the false coal measures, are the first of any great size that we come to, and they are nearly always found in a valley or well down toward the eastern foot of a ridge. On top of this ridge is a grayish coarse sandstone full of very small pebbles and looking very much like a subdued sort of millstone grit. This sandstone is marked by false bedding, the strata being cracked into blocks and built up somewhat like rubble masonry. Resting on this gray sandstone the false coal measures are found as a succession of thin coal beds and thick slates or shales, alternating with each other.

This coal outcrops in many places along the line of the Appalachian upheaval from the Susquehanna River to the Coosa River, in Alabama. It is found near Harrisburg in a spot where a great deal of money has been spent to develop it, but no valuable results have followed. It is found again on Sideling Hill, in Maryland, and in the valley of Meadow Branch, west of North Mountain, on the road from Martinsburg to Bath, in West Virginia. At this place a shaft seventy feet deep passed through five beds of coal, anthracite in character, but worthless, as the writer gouged out handfuls of the coal from the exposed surface of each bed. The five beds made up a thickness of eighteen feet, but the coal was simply coal dust and would not stand any sort of handling.

The Dora coal mines, near Rawley Springs, are of this same horizon, but the coal is in better condition and some of it will bear transportation. This coal comes to the surface once or twice in the lateral valleys running into James River below Clifton Forge, and again at Brushy and Price's Mountain's, near Christiansburg, Virginia. These two localities supply a fair-sized neighborhood demand with a tolerably good semi-anthracite coal, but the people don't know how to use it to the best advantage, as they burn it in open grates and otherwise as bituminous coal is used. The beds at these mines are only two or three feet thick, and but one bed at each place. One of them has the bed folded over on itself, giving double thickness.

Near Martin's Station, on the Norfolk & Western Railroad, there is another opening on the false coal measures, and here they find a thirty-inch bed of good semi-anthracite, and a twenty-foot bed of crumpled coal. The owners work the good lump coal and anathematize the coal dust and make a little money both ways. The writer thinks that careful examination will develop this bed of lump coal in larger size at points to the south and southwest from the present mines, and some sixty or more miles distant, in the hills between New River and the Upper Holston.

These false coals occur at several places along the base of the Cumberland Mountain, and again in the eastern foot-hills of Lookout Mountain, near Dalton, in Georgia, where they have been worked without valuable results. Also, in the bed of a creek three miles from Gadsden, Alabama; while the lower beds of the true coals are found on top of Lookout Mountain, only a mile or two off.

We are thus particular about this semi-worthless stuff, as we know that money will be saved to some of our readers. We have been professionally retained several times to examine grounds, where heavy money spending was going on, and advise owners what to do, and we have seen a great deal of money lost in pushing operations against our advice. The same terrestrial disturbance which cracked the gray pebbly sandstone and false bedded it was certainly the force which crumbled the coal, and the chances are overwhelmingly against success in any venture depending for a profit on sending the coal to market. The market won't have it. Where limestone and iron ores are near by, something might be done by burning lime, and possibly iron could be smelted by balling the coal dust with coal tar, etc. It might be used as a low-grade fuel for steam power, by using very large fire boxes. It actually is used for boiling salt water at Saltville, Virginia, and for smelting zinc ore at Martin's Station.

LOWER COALS.

These coals furnish three-fourths, at least, of the entire coal supply of the world. The fourth great sandstone, the one which caps the main Allegheny backbone, is the distinguishing mark of these coals, and is called the conglomerate or mill-stone grit. The coals are both above and below it. The sub-conglomerate coals commence in the valley of the Kanawha River, near Quinnemont, and continue thence to the southwest into Alabama. Between these coals and the false coals there are several hundred feet of sandstones, slates, shales and shelly limestones, in Pennsylvania, but these all graduate into a mountain limestone as we go south, and in the Cumberland Mountain we find false coal at the base, then five to seven hundred feet of blue and gray limestone, then shales, etc., containing two good beds of true lower coal, capped over all by the conglomerate. The conglomerate is the table rock of the elevated plains on the mountains, but there are terraces on top of this table land, which terraces are made up of the shales, slates and coals which in Pennsylvania produce the anthracites, and in Maryland are found near Cumberland. The Sewannee coal mines of Tennessee are in these terraces.

The sub-conglomerate coals are the coals worked most extensively near Chattanooga, but one or two of the terrace beds are also found, and at a point some thirty miles up the Tennessee River there is a great thickening up of the coal beds, and very fine gas and coking coals have been recently discovered. The heavy beds now being developed near Cumberland Gap are also mostly sub-conglomerate coals, and the same is true of the Coal Creek beds.

The Coosa, Cahawba and Black Warrior coal fields of Alabama are also in the sub-conglomerate, and furnish most excellent coal. Fortunately, the existence of enormous iron ore beds, and the presence of the mountain limestone, and the good coking qualities of much of the coal render its immediate and local utilization very profitable, and, in fact, there are very few localities in this country so favored in these respects.

The Illinois coal field, extending into Indiana and Western Kentucky, is now considered to belong to this sub-conglomerate division. In Illinois, the coal near Muddy River, below St. Louis, is a most excellent coal; but the coal of about all the rest of the State is very inferior, containing sulphur and all sorts of deleterious impurities. It, however, underlies three-fourths of the State, and can be dug up on almost anybody's farm, so that it compensates for the absence of timber on the prairies, so far as domestic fuel is concerned. In Indiana the eastern edge of the coal field, from Brazil down to the Ohio River, affords a very valuable variety of splint or block coal, which holds the "burden" in an iron furnace very well, and is used raw.

In Kentucky these sub-conglomerate coals afford a very rich, oily cannel coal in the region of the Tradewater River. It is called Breckenridge coal, and is a fine material for the distillation of paraffine and the mineral oils.

There is a coal field in Michigan which is also referred to these sub-conglomerates, but as it only contains one bed about three feet thick and of very impure coal it is not of much importance except for household and local use.

West of the Mississippi River there is a fine lay-out of coal, extending in broken doses from Central Iowa down through Missouri, Kansas, Indian Territory, Arkansas into Texas. It keeps mainly to the west of the Ozark mountains, and it has coal beds which are allied to the sub-conglomerate and to the beds above the conglomerate also. There is, undoubtedly, some very fine coal in Iowa and Southeastern Kansas, much of it being fair coking coal. This coal field is larger in area than the Appalachian coal fields, but it has only two to four workable beds, and none of these have over five feet of thickness. The writer suggests that this whole field should be named the Ozark coal field, for it really surrounds the Ozark mountain range. The Iowa end of it curves down to St. Charles, eighteen miles from St. Louis, and from thence it is found in small isolated troughs down through Eastern Missouri and Arkansas into Texas, in many places being anthracited, presumably by the heat of the Ozark upheaval.

Returning now to the Appalachian coal field, we will begin on the conglomerate and work upward. The first coal bed of any value we come to is the Lower Kittanning, which in the East is known as Buck Mountain Vein. There are sometimes three beds of this separated by shales and clays, and it is really a group of beds. The bottom bed furnishes a block or splint coal, while the other two are simply good coal, anthracite in the east and bituminous in the west. The three beds aggregate in many places about ten feet in thickness, and sometimes they are found with merely clay partings between them. The Upper Kittanning coal comes next, and in the northern part of the coal field it is not found thick enough to work. It is, however, the great cannel coal-bearing vein, and is the cannel coal of the West Virginia and East Kentucky regions. These Lower and Upper Kittanning beds are separated by a micaceous sandstone of considerable thickness, and they are the coals of the Clearfield region, the Broad Top and the Allegheny Summit and Stony Creek Valley regions.

Next above these, with about a hundred feet of soft shales supervening, comes the Lower Freeport coal, which ranges about four feet thick of excellent coal, which cokes well. Then come in more shale and sandstone and an eight-foot bed of limestone; then a little more shale, and we come to the Upper Freeport coal, called in the East the Mammoth Vein, and in Cumberland the Big Vein. In the anthracite regions this vein is sometimes one solid bed fifty to sixty feet thick, and sometimes it is a group of two or three thinner veins. In the Cumberland region it is fourteen feet of the best semi-bituminous coal. These two Freeport coals are also found in the Stony Creek region, where the Big Vein is reduced to five or six feet in thickness. The Cumberland coal basin contains all four of the groups of the lower coals above the conglomerate, viz.: the two Kittanning groups and the two Freeport groups.

These are all the valuable beds of the lower coal measures, and the whole series is capped and overlaid by the great Mahoning sandstone, which is the fifth great plate of sandstone above the primary rocks. This sandstone is found in the anthracite regions, but has not been definitely recognized in the Cumberland region or elsewhere to the east of the Allegheny backbone. It forms the table rock of Ohio Pyle Falls on the Youghiogheny River above Connellsville, and dips under the great Pittsburgh basin, re-appearing in Ohio close to the Pennsylvania line. Everywhere west of its re-appearance the beds of these four groups of lower coals come up to the surface again, and the great Ohio coal region commences and continues westward until these coal beds "peter out" as they approach the axis of the great "Cincinnati rise."

All down through West Virginia, Southeast Ohio and Northeast Kentucky, this great trough of Mahoning sandstone, underlaid by the lower coals, continues, and the Ohio River runs along the centre of it as far as Huntingdon, when it suddenly turns westward and cuts out through the side of the trough owing to the elevation of the country south. The Mahoning sandstone itself thins down and peters out in the neighborhood of Pound Gap, and from there on down the table-lands of the Cumberland mountains the lower coal beds have no effective roof over them, and so we find them being more and more washed away until, in time, they exist only in terraces on top of the conglomerate table-land, as at the Sewannee mines, in Tennessee. Here and there we still find patches of the old Mahoning sandstone on the mountain between Pound Gap and Cumberland Gap, and they roof in some magnificent coal deposits.

UPPER COALS.

The inside of this great trough of the Mahoning sandstone is filled up with the slates, shales and coal beds of the upper coal measures. The first coal above the sandstone is a bed of five or six feet thick, called in the anthracite regions the rough-bedded coal, but west of the mountains this bed is split up into two or more beds, and frequently they contain cannel coal. Altogether they are not very valuable, as is evidenced by the fact that they underlie Pittsburgh and vicinity, at a depth of seventy feet below water level, and have never been worked, nor do they affect the value of lands to any extent.

About three hundred feet above these semi-valueless beds comes in the great Pittsburgh bed, the king of the upper coals. This bed runs south from Pittsburgh along the Ohio and Monongahela Rivers, and is mined everywhere en-route. It peters out among the headwaters of the Cheat, Monongahela, Tygart's Valley, and Little Kanawha Rivers, in West Virginia. The petering out is owing to the presence of a great transverse axis of upheaval running east and west from Point Pleasant, on the Ohio River, to the backbone of the main Allegheny mountain, near the junction of Pendleton and Pocahontas counties. This transverse axis is the watershed between the rivers above named and the waters of the Greenbrier, Elk, Gauley and others, flowing into the Great Kanawha River.

This Pittsburgh bed is not entirely identified in the valleys leading into the Great Kanawha River, but, undoubted, areas of it are found in the Big Sandy and the Guyandotte valleys beyond the Kanawha, and the better opinion is that it is also in the Kanawha valleys, and only needs more study to bring about its complete recognition.

This Pittsburgh bed is known in the anthracite regions as the Primrose Vein, and it is there only seven to ten feet in thickness, thus being the only bed that does not follow the general example of the rocks and thicken eastwardly.

There are several coal seams in these upper coal measures above the Pittsburgh bed, but they are not of much importance. The condition of affairs on the earth appears to have begun to change about this time. Local disturbances set in and tossed the surface up in one place, or let it down in another, and the consequence was that coal beds formed during such times are found to be thick in one place and thin in others. Big pockets succeeded by feather edges are the prominent features ; but the big pockets are, nevertheless, very valuable when found, and it is worth any man's while to look for them.

TRIASSIC COALS.

From the end of the great Carboniferous age until the Triassic age of the Mesozoic time there appears to have been no coal-making business carried on by the builders of this continent, but in Europe the Permian formations are coal bearing. In Europe also the Triassic coals are quite extensive, but on this continent they are insignificant. We mention them here because, though so small as to size, they have already been of immense importance in that the Triassic coals of the Richmond coal basin fed two-thirds of the fires in the Southern arsenals and iron works, and kept the late civil war going for at least two years longer than it would otherwise have lasted The other one-third of the fires were fed by the sub-conglomerate coals of Alabama and Southeast Tennessee and North Georgia.

These Triassic coals are found in beds in the bottoms of the great troughs in the primary rocks, which troughs are filled up with the New Red sandstone and its accompanying shales, etc. For further details regarding these sandstones the reader will consult the chapter on Bed Rocks. These coals are found in three coal fields, one at or near Richmond, Virginia, one on Deep River, North Carolina, and one on Dan River, same State. The latter is small, and the coal is sandy and the beds are few and thin, so that it will never accomplish the old champion feat of "setting the Thames on fire." The Richmond (sometimes called the Chesterfield) and the Deep River coal basins are both valuable, and contain each four or five seams of tolerably good bituminous coal.

Some of the seams are five to six feet thick, while others squeeze down to less than a foot, and they are all inclined to be irregular in thickness.

The coal makes a light coke, which proved its own value in the Southern foundries, and the location of the Richmond mines near tidewater is so advantageous that these coals and cokes are used in many of the Atlantic cities. They were the first coal mines worked in America, and they were used in Philadelphia and other coast towns long before the Revolution. One of the mines is now worked to a depth of more than two thousand feet, and is the deepest mine in this country, except those on the Comstock silver lode.

There are places in the Richmond coal basin where a fine natural coke is found, and its working is found to be profitable. It is always found in the vicinity of granite dykes, which show all the signs of having been injected while very hot. The coal has thus had all its more volatile constituents burned out, and the carbon has been left as a porous coke, which would probably have been a hard anthracite if it had age and pressure enough to compact it.

As stated in the chapter on Bed Rocks, the writer thinks he has recognized rocks of the Triassic age in South Carolina and Georgia, and he advises people in those States to keep an eye open for black dirt and slates or shales with fossil leaves in them, and other signs of coal or coal rocks. Good coal beds in the country between Augusta and Atlanta would be worth having; but don't get excited over the black dirts and earthy lignites found east of Berzelia, for they are not what is wanted.

TERTIARY COALS.

The coals of this age are the lignites, often called brown coals, and we have in the western half of this country the most important lignites of the world. They are now making as fine iron and steel in Colorado as is made anywhere, and their fuel is lignite and its coke. There are qualities, however, about this coke which render it unfit to use in some silver smelting, and eminently fitted in other silver smelting, and for this reason Connellsville coke is still shipped to Colorado and Arizona, etc. The writer is inclined to think that the peculiar qualities referred to are not in the lignite coke, but rather in the respective brains of the smelting masters.

There is a great difference to be observed in the respective modes of deposition of the older coals and of the newer coals or lignites. The beds of the regular bituminous and anthracite coals are continuous over wide stretches of country, some of them being recognizable at distances several hundred of miles apart, while the lignite beds of the Rocky Mountain regions rarely contiune as much as fifty miles.

They appear to be the result of peat moss growing in and filling up a large number of isolated ponds or lakes at various levels, rather than the growth of one solid peat bog over one vast area, as are each of the older beds.

There are points in the Rocky Mountain regions where seven and eight beds of most excellent lignite are laid one on top of another with thin layers of sandstone, shales, etc., between the coal beds, and on top of all the peat moss is still green. These lignite beds are nearly always thick enough to work standing up, and the amount of carbon thus stored up in that region where it is so much needed it truly enormous—sufficient for the mining operations of millions of years at the present rate of consumption. And, further, it is spread out in spots all over the whole area from the Pacific Ocean to the plains east of the Rocky Mountains. Much of it has been anthracited, particularly in the Southern Territories, and a new find is just announced down on the lower Rio Grande, in Texas and Mexico.

As stated in the chapter on Bed Rocks, the tertiary beds extend from Texas clear around to New York. At numerous points in Mississippi, Alabama, Georgia, the Carolinas, Virginia and Maryland, an impure lignite is found. It is in one bed or several, at different localities; and near Berzelia, in Georgia, one bed is nearly ready to become compact and resinous, while the rest are earthy. The general tendency is for these lignites to be worthless in the east, and grow better as they progress to the west, until in Texas they are worth looking for.

Some revenue steamers have recently supplied themselves with good coal from sandstone cliffs overhanging the sea in Alaska, and prospectors are outfitting to begin mining there. The character and geological position of this coal is as yet unknown, but the reports show that there is a likelihood of soon getting our seven millions of money back out of Seward's purchase of that frozen land.

III.

OIL AND GAS.

PETROLEUM—OIL AND GAS BEARING STRATA, OIL AND GAS CATCHING STRATA, OIL BREAKS, OIL AND GAS SPRINGS, OIL AND GAS PROSPECTS.—REMARKS.

PETROLEUM.

This is hydro-carbon, the two elements being in such varying proportions that no general analysis and description can be given. The first thing to be remembered is that petroleum means rock oil, and does not mean coal oil, and with this as a key the geologists have unlocked many of the so-called mysteries of its occurrence.

It is found that ordinary hydrous uncrystalline limestone of the secondary and tertiary formations contains both the hydrogen and the carbon, and that coal also contains them, and further, that the chemists have made ordinary petroleum out of both limestone and coal in their laboratories. It is also a fact that very little oil has ever has been found in or above the coal measures, or in any district where it is at all l kely that the true coal measures previously extended.

The petroleum fields east of the Mississippi River are all in districts underlaid by the lower secondary rocks, but the oil is not all confined, like coal, to one certain group of rocks like the carboniferous group, but it is found in several groups. In Canada oil is found as low down as the Trenton limestone of the lower Silurians, and this is believed to be the lowest position in which we can hope to find it, on account of its proximity to the metamorphic rocks.

Next above the Trenton, the Niagara limestones and shales show the first attempt at bituminization, as found at Chicago and elsewhere. This rock will burn for a considerable time, but does not make an ash, and oil has been made of it by boiling and skimming the oil off the water surface.

At other points in Canada the Lower Helderberg limestone seems to have produced oil, which has lodged in the Oriskany sandstone above it. The Marcellus shales, which are bituminous, appear to have been charged with hydrocarbon from the Upper Helderberg limestone just below them, and they produce oil in paying quantities at Canadian points.

Next above these come the Genessee slates and shales, which are also bituminous, and are the principal sources of gas supply for the city of Erie and many towns in that region. The Chemung group of coarse, gritty shales is the great basin or porous strata in which the great bulk of the oils produced among the many beds of limestone below appear to have been caught in their upward movement, and have been penned up for man's use when he should come of age. Oil is also found from this Chemung group all the way up to the base of the coal measures, but not in paying quantities. In the oil regions these different beds of porous rocks are called, locally, the first, second, third or fourth "sandrock," and so on.

It is to be noted that the great oil-holding strata are always regular beds, and they are also sandstones, conglomerates, or cavernous limestone. The fine-grained slates act as roofs to the porous rocks, and the fine-grained limestones act in the double capacity of roofs to catch the oil coming up from below, and as generators of oil to be caught above.

The earth's crust wherever dug into is found to have a local standing water level, and all the porous or permeable rocks below that level are water-soaked down to as low a level as man has yet reached. Oil generated in the lower rocks, being lighter than water, works its way upward until it is stopped and collected in the first anticlinal axis (trough turned upside down) of impervious rock it meets. It collects under the crown of this anticlinal or arch and saturates all the porous rock below the impervious stratum, while the surplus water leaks out through fissures under the bottom edges of the trough.

If more and more oil accumulates, the line of the oil bottom falls lower and lower until some of the oil gets out along with the water under the edge of the trough, or through some crack or fissure higher up, if such there be. This leaves all the porous rock under the impervious arch saturated with oil down to the level of the leak. If any of the oil turns into gas it collects at the top, right under the crown of the arch, and it is the first thing to be struck by a drill.

The fissure or leak level may be thousands of feet below the surface of the ground, and there may be one or more other strata of impervious arched rock above the one we have been discussing. In this case, the oil escaping from the saturated oil-catcher below will be caught again by the next arch, where it will accumulate and saturate all the porous rock until it establishes a leak, starts again on its upward journey, is caught by another arch, saturates another body of porous rock, finds a leak, and finally appears on the surface as an oil spring. A drill hole sent down from the surface through these arches will successively and successfully tap these reservoirs of imprisoned oil in the saturated rocks, and the water pressure under them will raise the oil.

The flat, gently-curved arches or anticlinal axes are very much more apt to contain oil than the sharply curved ones, as the latter nearly always are more or less fractured at or near the crown of the arch, and the oil has passed right through into the miscellaneous strata above and been dissipated. These fractures at or near the crown of the arch, when they are on the surface, show up a lot of broken and tilted rocks, more or less porous, and saturated slightly with oil, which oozes out at the bottom in oil springs.

These oil springs are always sluggish, and they arise from the downward drainage of the oil, since the upward hydrostatic pressure has been relieved by the fracture of the impervious strata. These springs have very little oil behind them, and are of use principally as arguments advanced while selling the property to more verdant operators, who are apt to lose their wits when they see great cliff-like masses of oily-smelling rocks with oil springs oozing out at the base.

These broken-backed anticlinals are called "oil breaks," and they may be badly broken all the way down to the deep, or they may be only broken among the upper arches, and the lower ones may be full of oil yet. Again, one end of an oil break may be but slightly broken, and produces a light volatile oil, while the other end, many miles away, may show fissures filled with asphalt or other mineral resin left by the oil as its lighter and more volatile portions evaporated long years ago, while the middle portions of this same oil break may be yielding quantities of valuable heavy lubricating oils.

There are as many different aspects presented by oil districts as there are differences in degrees of curvature of arches, and differences in directions of streams. A stream system which cuts across the axis of upheaval will present an entirely different topography from a system which cuts diagonally, or which runs lengthwise with those axes, and when all three systems or any two of them are found uniting with each other to drain the district the result is a very complicated country, most fearfully and wonderfully made, and requiring intelligent study to prevent "dry-holing."

The presence of sluggish oil springs is something which requires skilled brains to decipher. These springs can just as well come from valuable reservoirs of oil below as from the simple drainage of semi-saturated rocks above, but it requires trained brains to find out which case it is that is presented, and square miles of country may have to be critically examined before the underground structure can be made out.

Another feature in oil districts, often misunderstood or overlooked, is that a country may be to all appearances entirely barren of oil, and with no surface signs to be found, and yet it may be on the back of a wide-spreading underground arch so flat and gently curved that no one has noticed it. These are found to be the most productive of all the occurrences of oil, and the curvature is so imperceptible that it requires the use of instruments of precision to determine it. These very flat arches produce oil over wide strips of territory along their axis, whereas the sharper arches only produce it along a very narrow strip which is hard to hit.

We don't know the exact conditions under which the hydrogen and carbon in the rocks unite to form oil, and we don't know either how much oil comes out of the ancient bituminous slates and shales; nor do we know whether the oil and the bitumen are both the product of ancient life, animal and vegetable, which has become mineralized like coal; but the fact that large quantities of very good oil are now extracted from rocks and beds of the tertiary formation would seem to show that no one single source is to be credited with the production of all the oil. The oil found along the coast in California is all from the tertiaries, and so is that which is now being delivered at points on the Union Pacific and Central Pacific railways.

There are reasons for thinking that oil territory will be found along the crowns of the lateral ridges on either side of the Ozark Mountain upheaval, from Missouri down to Central Texas. Crowley's Ridge, in Arkansas, seems to promise good prospects. The southwestern prolongation of the "Cincinnati rise" down about the Muscle Shoals of the Tennessee River, or around the headwaters of Tombigbee River, in the same neighborhood, also promises well. The country to the south of Chattanooga contains oil, but it is in semi-saturated rocks with downward drainage, owing to the sharpness of the anticlinals and the consequent fissures in the crowns of the arches. Any wide-spreading, uncracked anticlinals in that country deserve attention, as the thickness of the Devonian and Silurian rocks there is greater than anywhere else in America.

REMARKS.

The great development of natural gas in recent years is not a new discovery at all, for these gas holes have been found nearly everywhere that petroleum has been bored for, and the gas is now thought to be the oil itself coming up in the gaseous form under certain conditions of pressure, or release from pressure. The gas mostly comes from the Trenton limestone, especially in Ohio and elsewhere along the "Cincinnati rise," and those portions of this Trenton limestone that have much magnesia replacing lime are found to be most productive. This Cincinnati arch runs in a northeast and southwest direction, with a width of at least a hundred and fifty miles, and its western edge is marked by the ledge rocks forming the Ohio River Falls at Louisville, the Harpeth Shoals on the Cumberland River, and the Muscle Shoals on the Tennessee River.

The general history of the natural gas development shows that the gas has high pressure at first, and this pressure, ranging in some cases up to seven hundred pounds to the square inch, continues for a month or more, then begins to decline, slowly and finally gets down to such a point that the hole chokes up with salt water, or goes dry, and the industries depending upon it for fuel supply have to either get it from another hole or return to the use of the old reliable coal. The great gas companies around Pittsburgh are now testing processes for making fuel gas with which to replace natural gas, and thus to save their heavy investments in pipe lines, with very favorable prospects of success, too.

IV.

IRON AND MANGANESE ORES.

IRON—MAGNETITE, HEMATITE, LIMONITE, SIDERITE, PYRITE.
MANGANESE—GLANCE, PYROLUSITE, MANGANITE, PSILOMELANE, WAD, RHODOCROCITE.

IRON.

We all know what iron is, but nevertheless we will give the following description of it:

Gravity	7.7	Iron	100 p. ct.
Hardness	4.5		

Lustre, metallic; clearness, opaque; color, whitish-gray; feel, harsh; elasticity, flexible to elastic; cleavage, imperfect; fracture, uneven, fibrous; texture, massive.

Pure iron shows almost no fibre, the fibrous structure being imparted to it by its rolling and other manipulation. Until very recently it has been held that metallic iron is nowhere found on this earth as an earthly product, but that many masses of metallic iron in the shape of meteors are continually dropping in on us from outer space. There have recently, however, been discovered in Greenland some large masses of metallic iron projecting from fresh surfaces of broken lava, but the "find" has not yet been accurately described, and we will return to our meteoric iron, as the only shape in which metallic iron occurs in this world without the intervention of man. This meteoric iron usually contains some other native metals, such as nickel, cobalt, copper, tin, and occasionally some sulphides, chlorides, carbon, and phosphorous. Some microscopists have thought that they found remains of life in some of its first forms, but this has not met with successful verification. The principal ores of iron are the following:

MAGNETITE.

This is the black oxide, and its points are:

Gravity	5.1	Iron	72 p. ct.
Hardness	6.0	Oxygen	28 p. ct.

Lustre, sub-metallic; clearness, opaque; color, black to dark brown; feel, harsh; elasticity, brittle; cleavage, indistinct; fracture, uneven, sub-conchoidal; texture, massive, granular, crystalline.

This is the magnetic ore or loadstone, and appears to be the earliest concentration of iron in beds of its own after getting loose from the igneous or prime rocks. The iron in these rocks is generally protoxide, whereas the magnetite is proto-sesqui-oxide of iron.

The powder of this ore is not entirely black, but is slightly reddish, and its streak on a piece of hard black slate is still more reddish.

There is a variety of this ore which contains titanium, replacing a portion of the iron, and the addition of a little manganese, zinc, and alumina, make it what is called *Franklinite*, from which a peculiarly hard iron is made in New Jersey.

This ore is mostly found among the rocks of the primary formation, and is in veins and beds, some of which are of immense size. Some veins contain only magnetite, and others contain also hematite.

HEMATITE.

This is the sesqui-oxide of iron, and is the next step in the process of oxidation after the magnetite. Its descriptive list is as follows:

Gravity	4.8	Iron	70 p. ct.
Hardness	6.0	Oxygen	30 p. ct.

Lustre, metallic; clearness, opaque to sub-translucent; color, rusty gray; feel, harsh; cleavage, distinct, but not perfect; elasticity, brittle; fracture, uneven to sub-conchoidal; texture, lamellar, massive, granular.

The above description is of the purest variety, the *Specular*, and this is the variety which is found associated with magnetite in beds and veins. When this ore, which to a certain extent is crystalline, is washed down and re-deposited, it becomes earthy or chalky in texture, very red in color, and dull in lustre, with no cleavage. All these changes may take place and yet the ore may be just as pure as the original specular ore, but the chances are greatly against it, as it is almost certain to pick up impurities and carry them into its new bed.

When these impurities constitute any considerable proportion of the whole bed, and are principally sandy clay, the ore is called *Ironstone.* When the ore is very red and finely triturated it is called *Ochre* or *Dyestone.* When it contains many fossils it is called *fossiliferous.* There is also a variety called *Needle ore*, which is very hard to describe, but it looks like many bunches of needles, and the little fibres get into your skin and are very difficult to wash off. This peculiar structure is found also in limonite, much of which is fibrous, and is also called needle ore.

Like magnetite, this ore also has a variety containing titanium, and it is called *Titanic* iron ore, or *Menaccannite.* It also contains manganese and other substances, and sometimes the titanium about equals the iron in amount. It is rarely found except as squarish blocks of hard brown-black ore scattered around on the surface, or in small grains in the beds of streams. The powder and streak of titanic iron ore are brown-black, nearly the same as in magnetite, while the powder and streak of hematite are always a lively red.

Hematite can be slightly magnetic, and is found in the primary rocks with magnetite or by itself. Immense beds of it are found also among the secondary formations, especially those below the coal group. There are also valuable beds of it among the Triassic red sandstones. There are beds of this ore which are continuous over hundreds of miles of territory, and can always be found in the same place on the geological column, and between the same rocks. Such is the fossiliferous bed which forms the top of Red Mountain, in Alabama, and is traceable step by step clear up into Pennsylvania, where it is called the dyestone ore.

LIMONITE.

This is called brown hematite, and its points are:

Gravity	3.8	Hematite	86 p. ct.
Hardness	5.2	Water	14 p. ct.

Lustre, metallic to dull; clearness, opaque; color, dull brown or yellowish-red; feel, harsh; elasticity, brittle; cleavage, imperfect; fracture, uneven; texture, earthy, massive, fibrous, concretionary.

Probably more iron is made from this ore than from any other. It is erroneously called brown hematite, apparently because it is *not* blood-colored. It contains about sixty per cent. of metallic iron, and its powder and streak are always yellow. It is found presenting a vast number of physical features, and it is safe to say that any iron ore which you cannot distinctly classify under any other name is a variety of this limonite.

This ore appears to have been formed by the precipitation of iron oxide and water of hydration out of chemical solutions of other iron ores. The writer knows of a fissure between limestone and sandstone, which fissure is sixty to seventy feet wide, filled with clay, and a six foot vein or bed of pure limonite running through the centre of the clay. Near the outcrop, where the weathering has been greatest, the clay is nearly white and the limonite vein is thickest, but two hundred feet down from the surface the vein is only half as thick, and the surrounding clay is very red with disseminated hematite. It would seem that when this hematite is reached by the rain waters and other influences it is dissolved (as in the case of chalybeate springs) and concentrated at the middle line of the clay by attraction of the particles of iron for each other.

As might be expected, this dissolving and precipitating process results in a variety of composition, and many impurities creep in. Anything that the solution comes in contact with, and that it can dissolve, is sure to get entangled and deposited with the limonite, and thus it happens that nearly all limonite found in bogs and marshy places contains more or less of the phosphorus which is always to be found among decaying matters.

There are also degrees of hydration among limonites, and as the water of hydration must be roasted out of the ore the amount of the water is a consideration of some importance. The ore *Gothite* is an incomplete limonite, and contains only ten per cent. of water to ninety per cent. of hematite, and its powder and streak are more reddish-yellow than the pure yellow of the limonite. The ore *Turgite* is another incomplete limonite, and contains only five per cent. of water to ninety-five per cent. of hematite, and its powder and streak are nearly as pure red as those of hematite.

Limonite is found almost entirely among the secondary and later formations, but it is to be looked for everywhere, as it is the most universally distributed of all the iron ores. All three varieties are often to be found in the same bed, but the full-watered limonite is more abundant than gothite or turgite.

SIDERITE.

This ore is also called *Chalybite*, *Hone ore*, *Spathic ore*, *Clay ironstone*, *Carbonate of iron*, and sometimes the richer ores are called *Black Band ore.* Its descriptive list is about as follows:

Gravity	3.8	Iron oxide	62 p. ct.
Hardness	4.0	Carbonic acid	38 p. ct.

Lustre, vitreous to dull; clearness, opaque to translucent; color, white-gray, light brown; feel, harsh; elasticity, brittle;

cleavage, perfect to imperfect; fracture, uneven; texture, granular.

This description allows of a deal of latitude, but that is because the ore itself occurs in many conditions. In its most common form it looks like a roundish mass of gray limestone, very fine grained, and which shows a concretionary structure inside. Sometimes these masses will show brownish layers on the outside with gray or white materials inside, and sometimes the brown will be inside and the gray outside. Another form of siderite is the crystalline, and this is so very translucent that you can almost see through it.

Very few iron carbonates assay up to more than forty per cent. of metallic iron, and the most of them range from thirty to thirty-three per cent., but, nevertheless, they are very valuable, as they contain few *deleterious* impurities, and smelt more readily and economically than any other ore, owing to the carbon in them. When very low in phosphorus they are also used by the best ironmasters to mix in with the richer ores, so as to reduce the percentage of the phosphorus and other deleterious impurities of the richer oxide ores, as well as to facilitate smelting.

The celebrated "Black Band" ore, from which the "Scotch Pig" is produced, is siderite, and so are the iron "Carbonates" of the silver mines near Leadville and elsewhere in the Rocky Mountains. This ore is found in all the formations, but it is most plentiful in the Carboniferous beds, where it occurs in regular strata intercalated between slates and shales and in coal beds. It is always mixed with more or less sand or clay, and sometimes it is not easily recognized even as a clay ironstone, although in this shape it is the great ore of England.

There is a sort of auxiliary ore of this variety which is called *Ankerite*. This ore is a mixture of thirty per cent. of siderite with twenty per cent. of magnesite and fifty per cent. of calcite, and a good body of it is valuable, as it carries not only its own flux, but also enough more to flux twice its own weight of the richer oxide ores. It is wanted by the ironmasters for mixing, and can be distinguished from ordinary limestone by the fact that it is more like marble in appearance, is ten per cent. heavier than marble, and will cut marble. The crystalline transparent siderite is the purest form of all these carbonate ores, but it is too rare to be wasted as a mere iron ore when it is so valued as a cabinet specimen.

PYRITE.

There are two iron pyrites, or rather iron sulphides, and there are also two more sulphides in which iron is a considerable ingredient. Their descriptions are as follows:

The common iron pyrite contains—

Gravity......................5.0	Iron....................47 p. ct.
Hardness....................6.3	Sulphur.................53 p. ct.

Lustre, metallic; clearness, opaque; color, brassy-yellow; feel, harsh to smooth; elasticity, brittle; cleavage, perfect; fracture, conchoidal, uneven; texture, cubic, granular.

There is a whiter variety of this ore which is called *Marcasite*, and which is slightly lighter in weight, but the differences are not great.

The ore *Pyrrhotite*, which is commonly called *Magnetic Pyrites*, is the richest in iron. It is as follows:

Gravity......................4.5	Iron....................60 p. ct.
Hardness....................4.0	Sulphur.................40 p. ct.

Lustre, metallic; clearness, opaque; color, deep yellow to reddish-yellow; feel, harsh to smooth; elasticity, brittle; cleavage, perfect; fracture, uneven; texture, granular.

The streak of this ore is dark gray, and it is magnetic. It is a little lighter in weight and much softer than pyrite, but it cannot be cut with a knife.

Mispickel is *Arsenopyrite*, or arsenical pyrites, also called *Mundic*, and its points are:

Gravity......................6.2	Arsenic.................46 p. ct.
Hardness....................6.0	Sulphur.................20 p. ct.
Iron.................34 p. ct.	

Lustre, metallic; clearness, opaque; color, grayish-white; feel, harsh; elasticity, brittle; cleavage, not perfect; fracture, uneven; texture, granular.

This ore is found among the primary rocks in veins along with the sulphide ores and compounds. The miners call it mundic, but, as they also apply the same name to other sulphides, it is not of much significance as a name.

The other sulphide containing much iron in its constitution is *Chalcopyrite*, which is described as one of the copper ores.

The upper parts of sulphide veins are usually oxidized into limonitic gossan above the water level, and these gossans are often valuable and pure iron ores.

It was true that a few years ago these sulphide ores were not used or counted as iron ores, but things are changing rapidly, and now, over in Spain and in England, they are first burning out part of the sulphur and making sulphuric acid of it, and they are next leaching the remainder of the sulphur together with the copper and part of the iron, and either making vitriols of them or are precipitating the copper in the metallic state. This leaching takes out all the sulphur, which mere burning could not do, and so the iron is left as an oxide of great purity.

REMARKS.

The great magnetite and hematite deposits of Lake Superior are the choice ores of America, and they are correspondingly high in price, while the slates, especially the Damourite slates of the Potsdam group, furnish the cheap brown limonite ores from which the great bulk of ordinary foundry and mill irons are made. The Alabama ores, now so prominent, are found in all the formations from the Potsdam up through the Clinton to the Devonian groups, and this is the case in North Georgia, East Tennessee, and Southwest Virginia.

MANGANESE.

This metal oxidizes so rapidly that it is never found native. Its description is:

Gravity....................8.0	Manganese..........100 p. ct.
Hardness, about..........3.0	

Lustre, mild metallic; clearness, opaque; color, grayish-white; feel, harsh; elasticity, brittle; cleavage, imperfect; fracture, hackly; texture, massive, crystalline.

It looks very much like white cast iron, and is used in making *Speigeleisen*, *Ferro-Manganese*, and for hardening other metals with which it is alloyed. It will not strike fire itself, but will cause its alloys with softer metals to do so.

MANGANESE GLANCE.

This is sulphide of manganese, and is very scarce; but as it is the source of all the other ores we will describe it:

Gravity....................5.0	Manganese..........63 p. ct.
Hardness...................3.0	Sulphur..............37 p. ct.

Lustre, metallic; clearness, opaque; color, greenish-black; feel, harsh; elasticity, brittle; cleavage, imperfect; fracture, uneven; texture, granular, cubic.

PYROLUSITE.

This is the peroxide of manganese, and is the first derivative from the sulphide. It is as follows:

Gravity....................4.8	Manganese..........63 p. ct.
Hardness...................2.3	Oxygen...............37 p. ct.

Lustre, metallic; clearness, opaque; color, grayish or bluish-black; feel, harsh; elasticity, brittle; cleavage, not perfect; fracture, uneven; texture, granular, massive.

This ore appears to be a clear case of the substitution of oxygen for the sulphur in the sulphide ore. The pyrolusite and the manganite ore next mentioned are both called peroxide of manganese by the market, and they both sell in New York for about seventeen dollars per ton. They are used for bleaching and many other purposes in which oxygen is needed, as they give it off at much lower heats than most other available minerals.

MANGANITE.

This is simply pyrolusite, with a little water of hydration mixed in. Its points are as follows:

Gravity	4.3	Manganese Oxide	90 p. ct.
Hardness	4.0	Water	10 p. ct.

Lustre, sub-metallic; clearness, opaque; color, steel gray to brown; feel, harsh; elasticity, brittle; cleavage, perfect; fracture, uneven; texture, fibrous, columnar.

The addition of a little water makes this one-half harder than the pyrolusite, but such things will happen. Besides, the manganese oxide in this ore is not exactly the same as the pyrolusite, there being a small difference in the proportions of the manganese and the oxygen.

PSILOMELANE.

This is a sure-enough mixture, and its points are:

Gravity	3.8 to 4.5	Oxygen	15 p. ct.
Hardness	5.0 to 6.0	Potash	5 p. ct.
Manganese Oxide	76 p. ct.	Water and Sundries	4 p. ct.

Lustre, sub-metallic; clearness, opaque; color, brown black; feel, harsh; elasticity, brittle; cleavage, imperfect; fracture, uneven; texture, massive to earthy.

This ore is harder yet than the other oxides, but it is often earthy, or rather disintegrated and very soft.

WAD.

This is a mixture of the three foregoing oxides, together with any dirt which may happen to get in. It is nearly always in the earthy condition and sometimes very light in weight. The copper miners often mistake it for black oxide of copper, and swear accordingly. It is apt to be in bogs and moist places, and varies so much in different parts of the same deposit that we will not attempt a description.

RHODOCROCITE.

This is carbonate of manganese or manganese spar, and its descriptive list is as follows:

Gravity	3.6	Manganese Oxide	62 p. ct.
Hardness	3.6	Carbonic Acid	38 p. ct.

Lustre, vitreous; clearness, translucent; color, gray, red, yellow, brown; feel, harsh; elasticity, brittle; cleavage, perfect; fracture, uneven; texture, granular, crystalline.

This ore is not so plentiful as the oxides, but it occurs along with them and is derived from them. They all occur in veins and beds among nearly all the formations but mostly in the secondary formation.

REMARKS.

Manganese ores and limonite iron ores are very apt to be found together, and the upper slates of the Potsdam group furnish the great bulk of manganese mined in this country. The Shenandoah Valley manganeses, notably the Crimora deposits, are in this group.

V.

GOLD AND SILVER ORES.

Gold—Vein Gold, in Pyrites, in Quartz, in Tellurium—Wash Gold, in Slate, in Sand, in Gravel, in Clay, in Sea Water—Gold Saving—Gold Testing. Silver—Silver Ores: Silver Glance, Horn Silver, Ruby Silver, Stephanite, Antimonial Silver, Miargyrite, Polybasite, Acanthite, Stromeyerite, Frieslebenite—Silver Saving—Silver Testing.

GOLD.

The descriptive list of this most interesting substance reads about as follows:

Gravity.....................19.3	Gold..................100 p. ct.
Hardness..................... 2.5	Value.............. .100 p. ct.

Lustre, metallic; clearness, opaque; color, royal gold yellow. All pure gold is the same lordly color, and variations are always due to impurities; feel, very smooth and comforting; elasticity, flexible, malleable, ductile in the highest degree; cleavage, none; fracture, wiry; texture, massive.

Gold is about as universally distributed throughout the crust of the earth as any other metal, and it would be very difficult to find a whole formation entirely barren of it. But yet, somehow, we can find so very little of it in any one place that the work of gathering it together is very apt to cost more than the gold is worth. Nevertheless, although it comes high, we must have it, for it has those peculiarities which render it a fitting standard of measurement for everything else in this world of finance, in that it combines more of the factors which produce unchangeableness in value than any other substance known to us. These factors are:

1. The greatest resistance to loss by chemical changes, in that it does not oxidize or tarnish, and it alloys most perfectly with other harder metals which protect it from loss by abrasion.

2. Most unmistakable physical characteristics to guard against counterfeiting. It is the only yellow native metal. Other yellow metals can be made by man by alloying red and white metals, but they cannot be made so heavy as gold, and they can all be touched and eaten by simple acids, whereas gold can only be touched by compound acids, such as aqua regia (nitro-hydrochloric acid).

3. Sufficient and reliable, but not excessive supplies of the metal.

4. Excessive cost of production to secure the locking up of large amounts of labor value in small coin packages, thus insuring high intrinsic value.

As regards this latter qualification, it seems that its intrinsic value very largely exceeds its nominal value, for it is now quite well determined that all the gold produced in this country in any one year amounts, in face value, to only about one-fifth the value of the labor and supplies of all kinds expended in the gold industry that same year. The prizes are few but they are big, very big, and the losses are so many, but so small and so well distributed among a class of men who don't care a continental anyhow, that we adventurous humans go on carelessly putting down five dollars and taking up one, having four dollars' worth of fun for change, and hoping that our turn will come next.

We work for our food and clothing in this world, although some of us do have terrapin and canvas-backs for food and clothe ourselves in brown-stone front houses. In temperate climates we are apt to overwork ourselves and produce a surplus which some of us expend in fattening kings, lords, politicians, star-route contractors, big standing armies and other absorbents; while others of us store the surplus up in various forms of wealth more or less subject to destruction, taxes and changes in value. This wealth or capital is always changing in value up or down, and in order to measure these changes we must have a substance as nearly free from change as possible to use as a recognized standard. This desideratum we find in gold, and as we must have it we pay in labor and supplies (the product of other labor) five times as much for the gold as the gold will buy back again, thus locking up irrevocably five values in one.

VEIN GOLD.

Although gold is distributed among all rocks and formations, its derivation from some earliest matrix is certain. Of course it came down originally out of the condensing gases along with all other terrestrial substances, but there are reasons for thinking that the golden rain was one of the earlier incidents of world building, and that it was subsequently covered up by the deposits of lighter substances on top. In fact, it is not at all improbable that gold may be one of the metals which are supposed to constitute the central core of the globe, and which make the whole mass of the globe of a specific gravity of 5.2, while that of the crust of rocks, etc., is only about 2.6 on an average. This fact alone proves a great concentration of heavy substances at the centre of the globe; and as gold is so heavy in its metallic condition, and so energetically resists combination with other high fire-proof substances which would lighten it, there is strong probability that gold is an important constituent of this heavy core.

Down among the bottom rocks of the primaries in the gneisses and granites we first find gold, and we find it associated with *Pyrites* or sulphide ores of iron, copper, silver and other metals. These sulphides are in veins, mostly true fissure veins, which open downwards into the great unknown, and show all the marks of having been filled with the pyritous ores by the injection from below of melted substance and its subsequent cooling and crystallization.

These fissures down in the lowest known formations and igneous rocks are generally filled from wall to wall with pyritous ores, but when we get up among the Huronian and lower Silurian rocks we find that great quantities of quartz are intermixed with the pyrites, and indeed the fissures are sometimes filled with quartz from wall to wall. Often the quartz and pyrites are in sheets or layers, alternating, accompanied by barytes, calcite, and other common gangue rock of veins.

It is an observed fact that the gold in the sulphides of the lower veins is infinitesimally small in grain, while that found up among the quartz is larger, and can even sometimes be seen in the quartz by the unaided eye. That in sulphides is so fine that very many particles are required to be gotten together to make a speck or "color."

No man likes to say straight out that there is a natural gold sulphide, yet many claim that these invisible particles are really atomic, just freed from combination with sulphur, and become visible when aggregating into molecules of gold. Others claim that the gold is in flakes, or rather films of infinite thinness intercalated between the little cubical crystals of pyritous ores, as are the mortars and cements in the joints of brickwork or masonry. Others hold that each particle of gold is enveloped in a block or crystal of pyrites, and is freed mechanically by the crushing of this crystal, or chemically by the oxidation of the pyrites in open-air weathering or in furnace treatment. Still another idea is that as gold in Nature is always alloyed with a little silver, copper or other metal, the sulphur lays hold of such other metal and forms a film of sulphide ore around the gold without actually combining with the gold itself. When this sulphide film is oxidized it becomes a film of oxide ore, and is then called "rusty' gold by the maledictating miners, who can't make their mercury lay hold of it.

In veins containing much quartz the gold is found in both the quartz and the pyrites, but that in the quartz is generally much larger in grain than that in the pyrites, although they may be in the closest proximity. Why this is thus, and how the gold traveled from the pyrites into the hard body of the quartz, are questions not yet answered satisfactorily. Then, again, the quartz will contain numerous little sharp-cornered cavities which formerly contained crystals of sulphides which have become oxidized naturally, and the cavities now contain the brown iron oxide dust and the minute particles of gold which have been released by the oxidation.

Gold is also found in veins of pure quartz with no admixture of sulphides, and no signs of there having ever been any there. In these cases the gold is all free gold, and apt to be in grains round in shape and large enough to be seen in the quartz with the naked eye, although very large fortunes have been made out of veins of this class in which the gold was invisible until the particles were concentrated. Some hold that the gold got into these quartz veins by precipitation from some chlorine or other chemical solution included in the silicious mother-liquor out of which the quartz was crystallized. Others, that the gold was washed out of an igneous vein and washed into the open top of the quartz vein; and still others assert that the gold was originally disseminated throughout the mass of the country rock, and was drawn into the fissure in some chlorine solution right through the wall rock by some sort of electricity.

It is well to reflect that, perhaps, all the theories may be be right, some in one place, others in other places, and some cases may be the result of all acting together, reinforced by others not yet stated; and the best we can do is to say, Quien sabe?

The pyrites of the coal measures rarely contain gold, nor those of the tertiaries, but as a general proposition all others do in greater or less quantity. Those ores having a fine grain are the most auriferous, while those having large, whitish crystals, very hard, are least auriferous.

The quartz intermixed in pyritic veins is vitreous quartz, and is nearly always auriferous, while vitreous quartz in a vein all to itself is rarely so. A quartz which has a granular, sugary appearance is frequently auriferous; and massive, milky-looking quartz is rarely good for much.

Sometimes a sulphide and quartz vein is found in which the sulphides have oxidized into a brown iron ore all the way down to the water level of the locality, and down to that level it pays to work it, as the gold is free from sulphur, but below that level the sulphides are hard and close, and the money made out of the upper levels goes back again into the mine in the lower levels, unless the workers have been sagacious enough to unload the property at the right time and give others a chance.

There is a true gold ore which sometimes is found and worked, but no one knows of any money that has ever been made out of it. It is called *Sylvanite*, and is a *Gold Telluride*, as follows:

Gravity 8.2	Silver ....16 p. ct.
Hardness 1.8	Tellurium.............56 p. ct.
Gold....................28 p. ct.	

Lustre, metallic; clearness, opaque; color, white to brass yellow; feel, rough; elasticity, brittle; cleavage, perfect; fracture, uneven; texture, granular to massive.

This is vein gold; but, although some good-sized veins of it are known, the stuff is so brittle that it breaks finer than sand, and cannot be washed out. .

WASH GOLD.

When a hill traversed by an auriferous vein is cut into and washed down by water, the materials of which it is built are spread out on the adjoining lower lands, and the vein gold thus carried away and deposited in strange places is called wash gold, or alluvial gold, or placer gold. A majority of the gold now in possession of man has thus been washed into piles by natural causes. We humans were very much more apt to pick up gold in river beds and gravel or clay banks than to drill out the hard rocks to get it, especially in the earlier days of the race, when we had not invented blasting powder, dynamite and other little conveniences. Now that we are older and are training up experts in mining as well as in medicine, etc., the percentage of total gold product credited to regular mining is much greater than that from washing and re-washing Mother Nature's piles of tailings.

It is evident that, from the time when the water first came down on the naked rock of the globe all the way to the present, there has been no period in which vein matter was not liable to be washed down and deposited elsewhere, and we must accordingly expect to find wash gold in any or all the formations down to the lowest point known. As a matter of fact, most of the gold in Georgia is found disseminated in minute particles throughout the whole mass of great formations of stratified slate rocks. Those slates are the micaceous, the talcose, the chlorite and the clay slates of the primaries. These slates are more or less gold-bearing over whole counties, and are sedimentary rocks, beyond all question, formed of the debris from the washing down of other rocks containing gold or gold veins. In other words, they are simply "placers" of the ancient days which have lain so long undisturbed that they have compacted into hard slates. The gold mines now worked in Brazil are of this nature and age of formation, and much of the Australian gold is similarly placed. Nearly all of the above-named slates along the Atlantic slope are auriferous, and in many other localities than those in Georgia they can be profitably worked.

On the coast of California there are great hills of alluvial formation forming clay bluffs with narrow sandy beaches. Every time a storm blows up such a sea as to wash up against the base of the bluffs the waves undermine portions of the bluff and wash the materials down upon the beach and out to sea. There is a little gold disseminated throughout the mass of these bluffs, probably a couple of cents' worth to a cubic yard, and while the waves wash out the clay and lighter portions the gold particles are dropped along the immediate shore, where they are collected by men who are not looking for big profits.

Among the foothills of the Sierra Nevada, on the California side, the streams which head in the Sierras all run westerly to the San Joaquin and the Sacramento, and they have cut out deep gorges in their passages through the foothills. These gorges cut across and reveal in cross section the gravel bottom of an immense ancient river which ran north and south high up among the tops of these foothills. The great river is no longer there, the water having been turned in some other direction by some upheaval, but the valley is filled up hundreds of feet deep by gravels, clays, etc., which in many places are roofed over by a great cap of lava, also hundreds of feet thick. Along the edges of the banks of gravel, forming the bed of the river, are found the remains of a race of creatures who used fire and made pottery, and otherwise behaved like men; and among the gravel itself is found the greatest quantity of gold that California has yet produced. The whole formation is called the Blue Lead, and the gold in the gravel is wash gold, derived from some gold region which has not yet been discovered.

Here in front of us is a plane hillside with moderate slope. Up near the top is a mass of auriferous quartz, but those other fellows don't know it, as it is covered by earth. It is the end of a vein, which has been there so long that a large chunk of it has been weathered and washed down the hillside. We fill a pan with earth and gravel, etc., dug down at the bottom of the hill, and take it to the nearest stream, where we wash it, until we find a little sand and just a color of gold left in the lower edge. We repeat this at points ten feet apart along the base of the hill, working each way until we cease to find a color in the pan. The distance along the base of the hill between the two points where we cease to find color is the base of a triangle, and the apex is the spot where we will find the end of the vein, if we go to the middle of the base, and then work straight up the hillside, panning the earth as we go, until we cease to find color in that direction also. Dig into the hill at that point and find the ledge, and remember that from that spot down to the base of the hill the wash gold spreads out like a fan. If the hill slope is not plane, but rather convex, the base of the triangle will be longer and the wash gold will be spread over a bigger fan; but if the face of the hill is concave the wash gold will be mostly confined to a narrow streak, and, therefore, more easily collected.

When the hill slope is so very concave as to amount really to a valley or gulch, the wash gold will be found always in the bottom of the gulch, and at those points where little catch-basins are naturally formed. As a general proposition, the finer the particles of gold the further down will they be washed, so that the prospector may always count on finding something better up the hill when he gets very small colors in his pan.

The Potsdam sandstone, the great plate forming the base of the secondary formation, and forming the cap rock of the Blue Ridge, and also exposed in much less thickness on Lake Superior and on the eastern flank of the Rocky Mountains, has from two to ten cents' worth of gold disseminated throughout every cubic yard of it that has yet been thoroughly examined.

The brick clays along the Atlantic coast are all more or less auriferous, and it is estimated that there is more gold in the clay under the city of Philadelphia than would pay for the rebuilding of the city, but nevertheless the clay is worth more for bricks than for gold ore.

The water of the sea is found to contain a grain of gold to every ton of water, but that gold is most irrevocably locked up, although it is estimated to be greater in quantity than all the gold now in use. It is in the shape of gold chloride, and its existence in this condition induced a wise man of the West to "fix" a spring in California with some buried gold chloride, and then reproduced the gold in the presence of sundry victims, who bought some of his watered bonanza stock on the strength of it. They couldn't doubt their own eyesight, you know, and they have the stock yet as a permanent investment in experience, while the wise man has the money.

GOLD SAVING.

To get the scattered gold particles concentrated into one place, so as to possess them, is one of the great industrial problems of this day and generation, and several thousand patents on inventions for gold saving have been issued by the American Patent Office. Some of these inventions have been good, some very bad, and most of them merely indifferent. Those that have been good have been based on a close imitation of natural processes.

Nature uses water to cut down and spread out the hill containing the sulphide vein, and then lets the air act on the exposed sulphides for long periods, and they become oxidized, thus freeing the gold particles. Man does the same thing by digging out the sulphides, roasting them with access of air at high heat to drive off the sulphur, oxidize the ores, and set free the gold particles. Nature takes plenty of time to do her work, and she is not very short-lived, while man has but seventy years to live, and he must realize on his investment before he steps down and out.

Nature turns on her water again after having freed her gold, and by some mysterious process she aggregates her small particles into larger ones, and washes them down grade, concentrating them as they go at every little crevice or resting place, and driving the sands and impurities out of them and on down out of the way, so that man can come along afterwards and dig out the gold particles from their lodging places. Man pulverizes his oxidized sulphides, and, using water, he washes the ores down long sluices with riffles on their bottoms to imitate the crevices that were used by Nature to stop her gold, while the sands and other impurities were swept on down stream.

In general terms, the above two steps, viz.: the pulverization and oxidation to free the gold from *attached* impurities, and the washing and concentration to free the gold irom *intermixed* impurities are the necessary two steps in all processes of gold saving, but many additional small steps have been invented which facilitate matters. The chief of these is in the lugging in of mercury, which assists in two ways in separating the gold from its associate minerals. Mercury is a fluid and has a specific gravity of 13.6 commonly, but when entirely pure is 14. Now gold at a gravity of 19.3 will promptly sink in a bath of mercury, while iron oxides ranging in gravity from 3.4 to 5, or quartz or any other substance lighter than mercury will float on the surface of the bath. By stirring the auriferous sands around on the surface of the bath in such a way as to bring all the gold particles to the surface they will drop out of the sand and sink in the mercury.

The other way in which mercury assists in separating the gold is by amalgamating with it and forming a new compound metal. A gold coin put in a bath of mercury will disappear very quickly, first by sinking and next by amalgamation, and the gold can be recovered again by straining the mercury through a piece of chamois skin and then burning off the remaining mercury, leaving the gold in a fine, brown powder. This powder, mixed with some saltpetre and melted in a ladle, will leave a gold button containing all the gold.

In order to utilize mercury in this latter way the surface of the gold particles in the sand must be bright and clean of all greasy matters and rust. Metal must touch metal, or they will not amalgamate. The gold released from sulphides by natural slow oxidation is bright and clean, but that released by roasting is nearly always coated with a film of iron oxide, due to the rapidity of oxidation, and this film has to be broken up before the contact of metal to metal for amalgamation can be obtained. This is done to a large extent by grinding the pulverized ore in big pans having mullers working in them, and having mercury mixed in with the ore. The grinding polishes the gold and the mercury immediately lays hold of it, thus loading down each particle so that it can be more easily captured in the subsequent washing, concentrating and settling processes.

In the formation of vein matter by means of chloride solutions of gold man finds another of Nature's processes worthy of imitation, but he imitates it backward by saturating the crushed ore with water and then forcing chlorine gas into it. This gas dissolves the gold, and the solution comes out of the tub as an amber-colored fluid and the gold, in form of a rusty powder, is precipitated out of the fluid by pouring in a solution of sulphate of iron.

Man also imitates Nature again, and most successfully, too, by washing down whole hills by means of water. The Blue Lead of California was worked on a very small scale for some years by tunneling in on the gravel bed; but some men brought a hose pipe full of high-pressure water from a neighboring waterfall, and found that the water would undermine, cut down, and wash into the sluices more materials in one day than the same men could do with pick and shovel in a month. In a very short time the picks and shovels were all at work, for a hundred miles up and down the Lead, digging ditches and canals to bring the waters of the mountain streams and lakes down to the mines, and the new method was everywhere adopted. Sluices miles in length, eight and ten feet wide, with riffles, filled with mercury, every few feet of length, became the order of the day, and the farmers in the low lands began to complain about the silt and sand covering their farms and ruining them, and the laws now prohibit this method almost entirely, and it can only be used in cases where the miners buy up all the land which can be affected by their operations.

Some valleys were so filled up that the miners who were driven away from the old river bars by the filling up have again resumed work on the same bars, gaining access to them by sinking shafts down through fifty to a hundred feet of filled up sand, and then drifting from the shaft bottoms out over the old gravel beds in various directions.

There are differences of opinion among mining men concerning the advantages or disadvantages of dry washing, so-called, but there are large tracts of placer ground so situated that water cannot be obtained, and dry separation must be resorted to or the work abandoned.

A blast of air, whether natural or artificial, is a great thing in such districts. A space is laid out, beaten down hard, and the auriferous sands, well dried, are tossed up into the air, where the wind blows away the particles of lighter specific gravity and the heavier ones drop on the prepared floor. Several sweepings up and re-tossing finally result in a very fair concentration.

These dry placers as well as pulverized vein-stuff have been successfully worked by raking the sands over the top of a broad and shallow mercury bath, and the gold separated from the sands, whether rusty or not, by sinking into the bath while the sands were passed over the sides when thus "washed." If there was a liquid of about 6 or 7 specific gravity it would be a most valuable medium for this dry washing, as the gold would sink into it so much more rapidly than into mercury, while all ordinary refuse, even including black iron-sand, would still float on the surface.

GOLD TESTING.

The only absolute test for determining the presence of gold is by dissolving the specimen of rock or sand or other suspected substance in nitro-hydrochloric acid (aqua regia), and then pouring into the clear solution some dissolved sulphate of iron (copperas). This will precipitate to the bottom, in the form of a reddish-brown powder, any gold that may be in the solution. Rub this brown powder with the blade of a knife and it will come out in true gold colors. If you have weighed the specimen, then you can weigh the gold and ascertain the percentage of value in the ore. Aqua regia is made up of two parts hydrochloric (muriatic) acid and one part of nitric acid, and it is the only acid which will dissolve gold. Gold melts at about 2,600 degrees.

A usual method to ascertain practically the value of pyrites is to pulverize a weighed specimen to about the size of fine sand, then roast it at a red heat (not too hot) until no more sulphur fumes arise, then pulverize it again to as fine a grain as you can get it with a hammering and rubbing motion, then wash off all the lighter stuff by panning, then put it in a china cup with a half teaspoonful of mercury and mix it for half an hour with a wooden stick, then wash off everything except the mercury, then put the cup on a shovel and heat it carefully over a fire until all the mercury is driven off in fumes, and the reddish-brown powder left in in the cup is about all the gold there was in the specimen.

Quartz specimens can be treated in the same way. The roasting of quartz and suddenly dropping it hot into cold water is good for it.

SILVER.

This is another interesting substance, but not quite so interesting as gold. Its descriptive list, like that of all good things, is short, as follows:

Gravity	10.5	Silver .... 100 p. ct.
Hardness	2.6	

Lustre, brilliantly metallic; clearness, opaque in mass, but can be made so thin as to be translucent; color, silver white; feel, smooth; elasticity, malleable, with tendency to elastic; cleavage, none; fracture, uneven, and draws down into wire before breaking; texture, massive, but sometimes in crystalline forms.

Silver is not quite so well fitted for coinage purposes as gold. It is readily acted on by nitric acid and tardily by other simple acids. Our wives know how quickly it blackens when used in eggs, and what trouble salt gives them, and how much renovating silver requires after having been packed up any length of time. The sulphur in the eggs forms an important silver ore (the sulphide of silver) with the outer surface of the silver, and rubbing it off takes away just so much silver each time. The same is true of the packed-up silver, the tarnish being produced by the small amount of sulphuretted hydrogen which is always present in the air. The tarnish from salt is the chloride of silver, and reduces the weight of the silver as much as the sulphide does at every fresh polishing.

Silver is easily imitated by making up alloys of other less precious metals. The weight of silver is little more than half that of gold, and there are many metals that can be brought together to counterfeit it in weight and appearance. It is also considered that, with the opening up of the old silver districts of Mexico and Peru to the introduction of American miners and mining processes and speculators, the supply of silver will become excessive in the near future.

For these and other reasons gold is the standard among nearly all people of Teutonic parentage, including the Germans, British and United Statesians, and we (numbering one hundred and thirty millions of people, doing three-fourths of all business done in the world,) insist on measuring, buying, and selling silver according to a gold standard, not gold by a silver standard.

We use silver for money metal in all those cases where gold coin would be so small as to be easily lost, but there is still a point left which is not fully provided for. This point is the interval between fifty cents and five dollars of American money. A gold coin below five dollars in size is too easily lost, and a silver coin above fifty cents in size is excessively inconvenient on account of its bulk. To fill in this interval an alloy to be called "goloid" has been proposed, which shall be of gold and silver in stated proportions, so arranged as to make the one, two, and three dollar coins of sizes convenient but different from any other coin. At present this gap is covered by Treasury notes and by clumsy silver dollars, affectionately called stove lids, which no one wants to carry around, and which contain only about seventy cents' worth of silver, counted at present market prices.

The Treasury Department has recently put out a scheme for buying silver at current market quotations and paying for it in certificates calling for as many dollars as the silver is worth that day, these certificates to be paid in silver at market quotations on the day of presentation or in gold at the Treasury option. This scheme has been sneered at as being the same thing as the well-known pig-iron warrants scheme applied to silver, but it is really very different, for the iron warrant is paid in so many tons of pig iron, regardless of market price, while the silver certificate calls for so many dollars' worth of silver at the market price.

A very large and increasing business is done in this country through the mails, and much of this is paid for by remitting one and two dollar bills enclosed in ordinary letter envelopes, not even registered, for the thief rarely gets time to go through any but the registered mail. And this retail business, so long as one and two dollar silver certificates are issued, will continue to grow, and this book which you are reading will continue to circulate and do good, but all this will stop when we have nothing less than five dollars except silver coinage.

Silver is the favorite money standard among the Chinese and neighboring peoples, and were it not for the fact that these Asiatics absorb every year about forty million ounces of silver it is tolerably clear that the price of silver would drop to a much lower level than it now occupies, and in the near future, too. Let us hope that the gentry with the yellow exteriors may continue in the same frame of mind for ages to come, and even increase their demands for the white metal, for they are now the chief consumers of an important American product, and one, too, which, by the nature of things, we cannot protect against competition by a tariff.

Native silver is found in nearly all the silver ore districts, but it don't amount to much in any district, except Lake Superior. It is nearly always found intermixed with silver ores, and is the result of some sort of natural smelting, or of a decomposition process. It is found in grains in the massive native copper of Lake Superior; and in the Silver Islet mine it is the chief product of value. Silver Islet is a little rocky peak, sticking up out of the water a mile or so from the north shore of the lake, and is about sixty or seventy feet square. This little patch is a high point in a submerged dyke of diorite rock, and is cut by a vein fissure filled with carbonates of lime and magnesia as the gangue rock. Sulphide ores of zinc, copper, nickel, cobalt and silver are scattered through the gangue, and native silver in sheets, strings and nuggets is found as well as the ores. The little island was enlarged by coffer-dams, etc., and the mining is now down a thousand feet or more, and over three million dollars' worth of profits are said to have been made. This is about the only place where native silver amounts to enough to make it the main object, and this has now been worked out, after a large amount of profits have been put back into the hole. There are many rumors coming out of the woods on the north shore of discoveries of silver and gold, and every Spring sees its lot of cheerful prospectors going into the wilderness, and every Winter sees them coming out again to work for a living.

SILVER ORES.

About ninety-nine per cent. of all the silver in use has been reduced from the various ores of silver, of which there are four chief ones. These ores are never found absolutely free from admixture with ores of other metals, and their general condition is just the opposite. The following four chief ores are the important ones, the others being of comparatively rare occurrence except in laboratories and mineral cabinets:

SILVER GLANCE.

Argentite is the christened name of this ore, and the family name is *Silver Sulphide.* Its descriptive list is as follows:

Gravity	7.2 to 7.4	Silver	87 p. ct.
Hardness	2.0 to 2.4	Sulphur	13 p. ct.

Lustre, metallic; clearness, opaque; color, dark gray; feel, rough; elasticity, somewhat malleable; cleavage, none; fracture, uneven; texture, small granular.

This is the richest possible ore of silver, but it has a sad habit of getting itself mixed up with sulphides of other metals. Mixed with galena it makes what is called silver lead ores. Mixed with black jack it is in its worst condition, for it is extremely difficult to get the zinc out of it. This ore and the double sulphide of silver and antimony, called stephanite, are the big ores of the Comstock lode, the greatest depository of silver yet discovered.

HORN SILVER

This ore is scientifically called *Cerargyrite*, and is silver chloride, just as silver glance is silver sulphide. Its description is as below:

Gravity	5.4 to 5.6	Silver	75 p. ct.
Hardness	1.0 to 1.4	Chlorine	25 p. ct.

Lustre, resinous; clearness, translucent to opaque; color, gray to greenish-gray; feel, smoothish; elasticity, sectile to brittle; cleavage, none; fracture, small granular; texture, massive.

When long exposed to the weather this ore turns black, or purplish-brown. When freshly cut it looks much like wax or translucent horn, when pure, but when impure it resembles old dried putty. This is the great ore of the Leadville and other carbonate silver-mining regions. The carbonates which we all hear so much about are carbonates of lead and iron, and the silver chloride is mechanically intermixed with the carbonates of the other metals. These ores may be very rich in silver, and yet may look like so much sand—reddish, yellowish, or any other sandy color—and be passed over day after day without arousing curiosity. They have no sign of metallic lustre, and the only suspicious feature about them is their extra weight. These are called sand carbonates.

Another Leadville ore is the hard carbonate, which has to be mined and often blasted to loosen it. It has a decided metallic appearance, looking much like iron ore, and it contains sometimes many hundred dollars' worth of silver chlorides per ton. The chloride is so finely intermixed with the carbonate as to be indistinguishable in many cases.

While silver sulphides are mostly found in true fissure veins, the chlorides are found not only in veins, but in beds between other rocks and in pockets. The Leadville deposits are generally situated on the line of contact between a limestone and a sheet of porphyritic trap rock. Sometimes the carbonate and chloride bed or sheet will be fifty feet in thickness, and in a hundred feet distance it will shut down until nothing but a sheet or film of rust will separate the lime and trap rocks. The keys to unlock all the mysteries of these peculiar formations have not been found yet, but good progress is being made.

In the Silver Cliff district of Colorado there is an immense overflow or sheet of trachytic trap, which rock is impregnated throughout with silver chloride, and they just quarry the trachyte and send it to mill. They don't succeed well, as the silver only runs from six to fifteen dollars per ton, and they have not yet invented suitable milling processes to work such low-grade ores. It is to be hoped that a richer carbonate ore will be discovered in the neighborhood, so that the chlorides and carbonates can be mixed, and thus make up a good smelting ore.

There are fissure veins in that same vicinity which are filled with a gangue composed of pebbles and boulders of various kinds of rock, all cemented together by silver chloride, and there are others, where the fissure is filled with slabs, blocks and gravels, cemented in the same way with horn silver.

The great Horn Silver mine, in Utah, is believed to be a fissure vein, and is filled with all sorts of materials containing silver chloride intermixed throughout. In Arizona, the two ores, sulphides and chlorides, appear frequently in the same vein, the sulphides getting richer with depth and the chlorides poorer, and the third great ore, ruby silver, is frequently found mixed in with them.

RUBY SILVER.

This ore is also called *Pyrargyrite*, but we are not expected to use this name until it has been passed through the jaws of Blake's crusher a time or two. Its points are as follows:

Gravity................5.6 to 6.0	Sulphur ....18 p. ct.
Hardness ....2.1 to 2.4	Antimony.............22 p. ct.
Silver..................60 p. ct.	

Lustre, metallic-vitreous; clearness, opaque to translucent; color, red to black; feel, smoothish; elasticity, brittle; cleavage, between perfect and imperfect; fracture, conchoidal to uneven; texture, massive-crystalline. There is another variety, called *Proustite*, which is of a lighter red in color, more transparent, not so plentiful, and contains arsenic instead of antimony.

These ruby ores constitute large portions of the total product of some localities, but they are never found as the only silver ore present.

STEPHANITE.

This is very similar in composition to the ruby silver ores, but is dissimilar in appearance. Its descriptive list is as below:

Gravity................6.1 to 6.3	Sulphur................16 p. ct.
Hardness ....2.0 to 2.5	Antimony.............16 p. ct.
Silver..................68 p. ct.	

Lustre, metallic; clearness, opaque; color, black; feel, harsh; elasticity, brittle to slightly sectile; cleavage, none; fracture, uneven; texture, granular to massive.

This ore and the sulphide make up the main body of the silver ores of the Comstock lode, and this ore is found almost everywhere that silver is produced. It has the same ugly habit of associating with the zinc ores that the silver glance has, and it is even more difficult to corral the zinc and expel the silver, or corral the silver and expel the zinc, than in case of the straight silver sulphide.

ANTIMONIAL SILVER.

The description of this ore is as follows:

Gravity.....................9.8	Silver.....................78 p. ct.
Hardness....................3.8	Antimony...................22 p. ct.

Lustre, metallic; clearness, opaque; color, white; feel, rough; elasticity, brittle; cleavage, distinct; fracture, uneven; texture, granular.

Dysclasite is its other name, and it is not abundant, so far as known.

MIARGYRITE.

This is another silver ore, and its points are:

Gravity.....................5.3	Antimony...................42 p. ct.
Hardness....................2.3	Sulphur.................... 21 p. ct.
Silver...................37 p. ct.	

Lustre, sub-metallic; clearness, opaque to sub-translucent; color, black reddish; feel, rough; elasticity, brittle; cleavage, imperfect; fracture, uneven to sub-conchoidal; texture, tabular.

This is not an abundant ore, and there is a variety of it called *Hypargyrite.*

POLYBASITE.

This is another sulphide of silver and antimony, and its descriptive list is as follows:

Gravity.....................6.2	Antimony...................10 p. ct.
Hardness....................2.5	Sulphur....................15 p. ct.
Silver...................75 p. ct.	

Lustre, metallic; clearness, opaque; color, black; feel, rough; elasticity, brittle; cleavage, imperfect; fracture, uneven; texture, tabular, foliated to massive.

ACANTHITE.

This is a silver sulphide, and its points are:

Gravity.....................7.2	Silver.....................87 p. ct.
Hardness....................2.4	Sulphur....................13 p. ct.

Lustre, metallic; clearness, opaque; color, black; feel, rough; elasticity, brittle to sectile; cleavage, imperfect; fracture, uneven; texture, tabular.

STROMEYERITE.

This is another case of silver sulphide, and its descriptive list is as follows:

Gravity......6.2	Copper......31 p. ct.
Hardness......2.8	Sulphur......16 p. ct.
Silver......53 p. ct.	

Lustre, metallic; clearness, opaque; color, dark gray; feel, rough; elasticity, brittle; cleavage, imperfect; fracture, conchoidal; texture, massive.

The copper in this ore is enough to more than pay expenses, leaving the silver as profit.

FREISLEBENITE.

The German who named this ore has not yet announced its pronunciation, but its points are:

Gravity......6.2	Lead......30 p. ct.
Hardness......2.3	Antimony......27 p. ct.
Silver......24 p. ct.	Sulphur......19 p. ct.

Lustre, metallic; clearness, opaque to translucent; color, grayish-white; elasticity, sectile to brittle; cleavage, perfect; fracture, sub-conchoidal; texture, massive to tabular.

The last six ores are not known to be abundant, but are described, as they may yet be found abundantly.

SILVER SAVING.

The extraction of metallic silver from its ores is a complicated process chemically, but yet there are cases where the manipulation part of it is very simple. The first American process was that carried on by the aid of the Washoe pan, and was invented by the Comstockers, who wished to substitute cheap rotary motion for more expensive longitudinal sluice work. The silver sulphides are first stamped to the requisite fineness, then put into the big Washoe pans and ground still finer in water heated by steam, then quicksilver is put into the pans, the grinders raised, but stirring motion continued, until the silver has all been amalgamated by the mercury, after which the muddy liquid amalgam and all is transferred into settling vats, diluted with clear water, and afterwards washed like gold amalgam, and the mercury retorted, leaving the silver.

An improvement on this simple process was the dosing the pulp in the pans with sulphate of copper, which assisted in decomposing the silver sulphides. Roasting the ores with a percentage of salt chloridized the silver and drove out the sulphur; and many other chemical substances have been experimented with and produced result of more or less value.

One very quiet little plan of extracting silver is to leach silver chlorite (or roasted and chloridized silver sulphides) with salt brine; and silver sulphate (produced by roasting and oxidizing sulphide ores) can be leached by means of water acidulated with sulphuric acid. Strips of metallic copper will precipitate the metallic silver out of either the brine or acidulated water solutions.

The chloride ores can be treated by the leaching process also, but as they are usually mixed with carbonates of other metals, and these other metals will sometimes pay for the whole cost of extraction, the smelting process is the favorite in the chloride mines. The neatest smelting in the countty is done at Leadville.

SILVER TESTING.

To test a piece of lead ore for silver, dissolve it in nitric acid and drop in a piece of copper, when the silver will drop to the bottom if there is any silver. A little salt water dropped in instead of the copper will curdle up into white clouds in the acid.

To test copper ore for silver, dissolve the ore in nitric acid, and add some drops of muriatic acid, when a white precipitate will appear on the bottom if there is any silver in the ore.

The silver sulphides and chlorides can be detected by powdering them and roasting them with a little salt. Then put in mercury and amalgamate; wash and retort as in the case of gold.

VI.

COPPER AND TIN ORES.

COPPER—CHALCOPYRITE, ENARGITE, TETRAHEDRITE, CHALCOCITE, BORNITE, MELACONITE, CUPRITE, CHRYSOCOLLA. TIN — TINSTONE, STANNITE.

COPPER.

Copper is mostly derived from its ores, but the Lake Superior copper region furnishes great quantities of native copper. Its points are:

Gravity	8.8	Copper	100 p. ct.
Hardness,	2.8		

Lustre, metallic; clearness, opaque; color, red; feel, smooth; elasticity, flexible, malleable; cleavage, none; fracture, uneven, ragged; texture, massive.

Native copper is also found sparingly among the rocks of the Triassic group with the New Red sandstone, in the Atlantic States. A few localities are also reported in the Territories. All native copper is supposed to be derived from some of its ores, by some process of natural smelting or solution and precipitation. The native copper of Lake Superior is found in veins filled with quartz, spar, and epidote, and other gangue rock, which veins pierce the great trap range or dyke, and frequently extend into the Silurian sandstones on either side of the trap ridge.

It is supposed that the great trap dyke (which here makes semi-mountains twelve hundred feet high) was first upheaved and then split by shrinkage-fissures as it cooled; that these fissures were filled with gangue rock and copper sulphides after the usual fashion, and that these copper sulphides were afterwards smelted in place by a fresh attack of subterranean heat, which drove out the sulphur without giving access to oxygen enough to oxidize the copper. The result of this, or whatever operation it may have been, has been that the metallic copper is now met with in great masses, requiring years of labor to cut them up into pieces small enough to be handled. At other points in the same vein are found great bodies of vein rock stuck full of shot copper, like currants in a fruit cake. The stocks of the mining companies rise when they find the shot copper, as it is so easy to extract and send to market.

CHALCOPYRITE.

This is the leanest of the principal copper ores, but it is also the most important, as it is very much the most abundant. It description is as follows:

Gravity	4.2	Iron	30 p. ct.
Hardness	3.7	Sulphur	35 p. ct.
Copper	35 p. ct.		

Lustre, metallic; clearness, opaque; color, brass or light orange-yellow, feel, harsh; elasticity, brittle to sectile; cleavage, not perfect; fracture, conchoidal; texture, granular.

This ore is called copper pyrites, and it is the definite chemical compound, but it is not to be confounded with the many mechanical compounds usually called by that name. A ten-pound specimen of sulphide ore may contain nine pounds of iron pyrite, having one pound of true copper pyrite distributed through it in pieces, and yet the very wise will call the whole lump copper pyrites, and marvel much when the assayer reports it as containing only three and a half per cent. of copper.

ENARGITE.

This sulphide of copper and arsenic is as follows:

Gravity....................4.4	Copper..............48 p. ct.
Hardness..................3.0	Arsenic..............20 p. ct.
Sulphur..............32 p. ct.	

Lustre, metallic; clearness, opaque; color, gray to black; feel, harsh; elasticity, brittle; cleavage, perfect; fracture, uneven; texture, granular, columnar.

Varieties of this ore contain antimony or iron, and they are all found with other copper ores.

TETRAHEDRITE.

This is a big ore and deserves a big name, but the miners call it "*Gray Copper*" and fahlerz. Its description is:

Gravity................5.0	Sulphur...............30 p. ct.
Hardness.............3.5 to 4.5	Arsenic............... 7 p. ct.
Copper...............35 p. ct.	Iron.................. 5 p. ct.
Antimony............20 p. ct.	Zinc, etc.............. 3 p. ct.

Lustre, metallic; clearness, opaque; color, gray; feel, harsh; elasticity, brittle; cleavage, imperfect; fracture, conchoidal to uneven; texture, granular to massive.

This ore has still other relations, such as silver and mercury, and occasionally gold, which lodge with it at times. This ore and chalcopyrite are the great producers of the copper of commerce, and generally are associated in the same veins, together with chalcocite, which is the purest of the sulphides of copper.

CHALCOCITE.

This is also sometimes called gray copper, but its best name is *vitreous copper* or *copper glance*. It is very rich, will melt in the flame of a candle, and is found in veins with other sulphides. Its points are:

Gravity....................5.6	Copper...............80 p. ct.
Hardness..................2.7	Sulphur...............20 p. ct.

Lustre, metallic; clearness, opaque; color, gray; feel, harsh; elasticity, sectile; cleavage, indistinct; fracture, conchoidal; texture, granular to massive, crystalline.

BORNITE

This is the *purple copper*, or horse-flesh copper, of the miners, and is found in veins with other sulphides. Its points are:

Gravity	5.0	Iron	16 p. ct.
Hardness	3.0	Sulphur	29 p. ct.
Copper	55 p. ct.		

Lustre, metallic; clearness, opaque; color, coppery-red; feel, smooth to harsh; elasticity, brittle; cleavage, imperfect; fracture, uneven to conchoidal; texture, massive to granular.

MELACONITE.

This is the *black copper* of the miners, and its descriptive list is as follows:

Gravity	6.2	Copper	80 p. ct.
Hardness	2.0 to 3.0	Oxygen	20 p. ct.

Lustre, metallic to dull earthy; clearness, opaque; color, gray to black; feel, harsh to greasy; elasticity, brittle to flexible; cleavage, indistinct; fracture, uneven; texture, foliated to massive and earthy.

This black oxide of copper is most usually found as an upper layer in veins containing the copper sulphides, and results from the air and rain water getting into the upper portion of the vein and oxidizing the sulphides. Many copper veins in this country have large amounts of "*gossan*" on the immediate outcrop, resulting from the oxidation of the iron pyrites, and under this gossan, speckled with malachite, comes the black oxide of copper. Under this again comes the red oxide of copper (next described), and under this the copper sulphides.

CUPRITE.

This is the red oxide of copper, and is the rarest, as well as the richest, of all the principal copper ores. Its descriptive list is as follows:

Gravity 6.0	Copper .... 89 p. ct.
Hardness 3.6	Oxygen .... 11 p. ct.

Lustre, sub-metallic to earthy; clearness, translucent to opaque; color, red; feel, harsh; elasticity, brittle; cleavage, distinct to imperfect; fracture, conchoidal; texture, granular to earthy.

This ore, like the black oxide, is found at times in a crystalline condition, but also like black oxide, it is most often in an earthy condition and will soil the fingers if wet. The red colors of the pure ore are very brilliant and are much used for paint; but there is a rare variety called tile ore, which is a dark brick-red or brown, and contains iron oxides generally. These red oxide ores of copper are not nearly so abundant as the black oxides, but they are nearly always found in the same veins.

CHRYSOCOLLA.

This is the silicate of copper, and its descriptive list is as follows:

Gravity 2.2	Silica .... 34 p. ct.
Hardness 3.0	Water .... 21 p. ct.
Copper Oxide .... 45 p. ct.	

Lustre, vitreous to earthy; clearness, translucent; color, green-blue; feel, smooth; elasticity, brittle to sectile; cleavage, indistinct; fracture, conchoidal; texture, massive to earthy.

This is one of the minor ores of copper, but yet, as it is frequently found filling up good-sized seams and fissures in and about the main veins, it is of some importance. It looks very much like a bright greenish earth, and its gravity is so little that it is apt to be classed as non-metallic and disregarded by the non-expert.

There are still other ores of copper, but they are unimportant as sources of copper, and will be described under other heads when good for anything. The green and blue carbonates will be spoken of as malachite among Ornamental Stones.

One thing about copper ores worth remembering is they are always bright in their coloring, and another thing is that you can always cut them with an ordinary penknife, unless the lump contains a considerable amount of iron pyrites, which resist the knife.

Copper is coming into new uses every day, and the electrical men have to have so much of it that Westinghouse and others are buying up the big mines so as to insure themselves full supplies in case any more French copper syndicates disturb the market and make the metal scarce.

TIN.

This metal is not an American product to any great extent, but we include some points about it, as it is likely that deposits of it may be discovered thereby. Nearly all the tin used in the world comes from Malacca, Banca, Tasmania, Australia, and Cornwall. Some tin is found in Mexico, and is irregularly worked, and some is found in California, Missouri, and a few other localities in the United States, but it is nowhere mined within American jurisdiction, and we have to import all our tin and pay twenty to twenty-four cents per pound ror it. Tin is never found in nature in the metallic state, but we give its features, as follows:

Gravity....................7.3	Tin..................100
Hardness....................2.0	

Lustre, bright metallic; clearness, opaque; color, silvery-white; feel, smooth to harsh; elasticity, malleable; cleavage, none; fracture, uneven to conchoidal; texture, crystalline. The crystalline texture of tin is such that it gives out a crackling sound when being bent.

TINSTONE.

This is cassiterite, and its points are as follows:

Gravity..............6.5 to 7.0	Tin....................78 p. ct.
Hardness............6.5 to 7.0	Oxygen...............22 p. ct.

Lustre, vitreous to adamantine; clearness, translucent to opaque; color, brown to black generally, but gray, red, yellow at times; feel, harsh; elasticity, brittle; cleavage, none; fracture, uneven; texture, massive.

This is the great ore of tin, and from it is smelted about all the tin we have in use. There are considerable differences in appearance and structure among varieties of tinstone, and brilliancy of lustre sometimes gives way to a woody structure and appearance. This variety looks just like petrified wood, but it is not cleavable. This stone is found in regular fissure veins in all the primary rocks, and it is the only valuable metallic ore that seems to find a congenial home between vein walls of granite. Other metals only get into veins in granite when they can't help it. There are tin mines in the lower Silurian rocks in Australia, and very productive ones they are.

Stream Tin is tinstone after it has been washed down out of the vein-stone and deposited in the beds of streams along with sand and gravel. It is collected by washing, same as stream gold.

STANNITE.

This is sulphide of tin, containing only twenty-six per cent. of tin, and is not a plentiful or valuable ore. It is usually associated with pyrites of iron and copper, and the miners call it "bell metal" on account of its appearance and sonorousness. It is worked more for its copper than for its tin.

Notwithstanding the discoveries of tin ores in the Black Hills in Wyoming, King's Mountain in South and North Carolina, and at Vesuvius in Virginia, we have yet no productive tin mine of America.

VII.

LEAD AND ZINC ORES.

LEAD—GALENA, CARBONATE, PHOSGENITE, LEADHILLITE SARTORITE. ZINC — ZINC BLENDE, CALAMINE SMITHSONITE, ZINCITE, GAHNITE.

LEAD.

This metal is very plentiful, and rarely sells for more than four and a half cents per pound in pigs; but refined sells for one-fourth more. The points of lead are as follows:

Gravity	11.4	Lead	100 p. ct.
Hardness, about	1.5		

Lustre, metallic, dull; clearness, opaque; color, leaden-gray; feel, smooth; elasticity, sectile, flexible; fracture, uneven; cleavage, none; texture, massive.

As the fables go, lead has been found native in obscure localities, and specimens of it exist in mineral cabinets, but it is not met with in real life, except as derived from its ores. These ores are many and various, but a vast number of them are very rare, and don't amount to enough to waste time on. They are always found accompanying the following named principal ores, and so will not be lost or overlooked by the miner:

GALENA.

This is the great ore of lead. It is the sulphide of lead, and is found all over the world. Its descriptive list is as follows:

Gravity 7.5	Lead .... 87 p. ct.
Hardness 2.6	Sulphur .... 13 p. ct.

Lustre, metallic; clearness, opaque; color, leaden-gray; feel, smooth to harsh: elasticity, brittle to sectile; cleavage, perfect; fracture, even, to sub-conchoidal; texture, granular mostly, but also foliated, tabular, fibrous.

The grains of pure galena are nearly always cubical or tabular, but when these grains are rounded on the corners and very small, the ore is almost sure to contain some silver. Such great silver mines as the Eureka, the Richmond and the Albion are merely veins of galena carrying silver enough to pay costs and heavy profits, leaving the lead to come into market as an extra, which weighs upon the spirits of the Missouri lead miners. The Utah silver mines are also really lead mines, and their biggest profit, in many cases, comes from the lead.

The galena mines of Missouri, Arkansas, Iowa and Illinois are beds and veins in the magnesian limestones of those States. Some are in Silurian and some in Carboniferous groups, and the lead and zinc ores are found intercalated with each other, and, curiously enough, these beds will suddenly disappear at one level on top of a particular bed of rock and be found again beneath the bottom of the same bed.

There are in Southwest Virginia many very large beds of lead and zinc ores among the Silurian and Devonian limestones, and also many true veins. This is also true of the entire western slope of the Appalachians all the way down through West Carolina, East Tennessee into North Georgia, and Alabama to the Coosa River.

CARBONATE.

The proper name of this ore is *Cerussite*, but as the Leadvillians have got the great majority of all that is known to exist, and they insist on calling it carbonate, the rest of us will save trouble by calling it carbonate also. Its points are:

Gravity 6.4	Lead Oxide .... 83 p. ct.
Hardness 3.3	Carbonic Acid .... 17 p. ct.

Lustre, vitreous to resinous; clearness, translucent; color, light to dark-gray; feel, smooth; elasticity, brittle; cleavage, not always perfect; fracture, conchoidal; texture, massive to granular.

This and the ore phosgenite, next spoken of, are, with iron carbonates, the great ores of Leadville. There they are indiscriminately called "carbonates," and the silver is found in the shape of chloride mixed in with them. Cerussite and phosgenite, when in powder and demoralized generally, look like so much clay or earth, and can only be distinguished by their extra weight or by actual test. It is probable that rich carbonates are daily walked over in many places in the Eastern States without exciting suspicion.

PHOSGENITE.

This is another lead carbonate, and its points are:

Gravity	6.2	Lead Carbonate	49 p. ct.
Hardness	2.9	Lead Chloride	51 p. ct.

Lustre, adamantine metallic; clearness, transparent; color, gray to yellowish-white; feel, smooth; elasticity, brittle to sectile; cleavage, perfect; fracture, even; texture, crystalline, tabular.

The chlorine in this ore evidently has some connection with the chlorine in the silver ores at Leadville, and it is generally held now that both the carbonates and chlorides of lead and silver are resultants from the decomposition of galena and silver sulphides previously existing. The reader is referred to remarks on the formation of veins in the chapter on Bed Rocks for further suggestions on these decompositions.

Other lead ores are the following, but, as they are unimportant and only found in connection with sulphides or carbonates, they will not be described in great detail:

Anglesite is a sulphate of lead resulting from changes in sulphides.

Leadhillite is a sulphate and carbonate of lead resulting from sulphides.

Clausthalite is selenide of lead.

Zinkenite is sulphide of lead and antimony, and is more of an antimony ore than a lead ore.

Sartorite is sulphide of lead and arsenic.

Boulangerite is similar to zinkenite, being a sulphide of lead and antimony.

Bournonite is sulphide of lead, antimony and copper.

Pyromorphite is lead oxide with chlorine and phosphorus.

Mimetite is lead oxide with chlorine and arsenic.

Vanadite is lead oxide with chlorine and vanadium.

These wildcat ores are all good cabinet specimens, but none are abundant enough to be looked for as lead ores.

REMARKS.

Electricity is increasing the demand for lead greatly, as it is found that the lead plate for storage batteries and the lead piping for underground cables are the best.

ZINC.

This metal is not found native, but has to be extracted from its ores. Its points are:

Gravity 7.2	Zinc...................100 p. ct.
Hardness ....1.5 to 2.0	

Lustre, metallic; clearness, opaque; color, white; feel, harsh; elasticity, flexible, sectile; cleavage, imperfect; fracture, uneven; texture, massive.

Crude zinc, in the shape of spelter, sells at five and a half to six cents per pound, and refined sheet zinc at seven to seven and a half cents. There are five ores of zinc, as follows:

ZINC BLENDE.

This is the sulphide of zinc, called *Sphalerite* in laboratory and *Black Jack* in the mine. Its descriptive list is as follows:

Gravity 4.1	Zinc...................67 p. ct.
Hardess.......................3.7	Sulphur ....33 p. ct.

Lustre, resinous; clearness, translucent; color, whitish-yellow to brown; feel, harsh; elasticity, brittle; cleavage, perfect; fracture, conchoidal; texture, granular, crystalline.

Its color can be red or green or bluish, according to the character of impurities present. Iron is often present and colors the mineral dark brown to black. This ore looks much like a bundle of little balls of resin agglutinated by a cement of the same resin.

Although black jack is the bottom ore from which all other zinc ores have developed, it is the smallest actual producer of the two or three principal ores, and is the most subject to malediction of all ores. It is very refractory in the furnace, and makes refractory all ores of other metals that it may be mixed with. The silver men especially are worried by it, and its presence in the silver mines in many Western localities is the bottom reason for non-payment of dividends by many smelting companies.

Black jack is found in nearly all the mines in Southwest Virginia and on down the Appalachian range into Alabama, and a good deal of zinc and white zinc for paint is made from it. It is also found in Pennsylvania and New Jersey, and in the lead districts of Missouri, Arkansas and Illinois it is found with the lead.

CALAMINE.

This is the silicate of zinc, and is the great producing ore. Its description is as follows:

Gravity	3.0 to 3.7	Silica	25 p. ct.
Hardness	4.6 to 5.0	Water	8 p. ct.
Zinc Oxide	67 p. ct.		

Lustre, vitreous; clearness, translucent; color, white; feel, harsh; elasticity, brittle; cleavage, perfect; fracture, uneven; texture, granular, crystalline.

Calamine can present many very different appearances. The pure crystalline variety is simply a block of clear crystal, but when this has been treated to a little washing and stirring in water and allowed to settle and get dry it looks much like whitish-clay or shale. When it has sand and other impurities in it its color is correspondingly changed, and few inexpert people would take it to be metallic ore. To further complicate matters, there is another ore called *Willemite*, which is also a silicate of zinc, but contains no water, and the two are nearly always found together. They both are resultants of the decomposition of black jack. Calamine and the carbonate ore next spoken of are the main sources of supply for zinc

SMITHSONITE

This is the carbonate of zinc, and its descriptive list is as follows:

Gravity	4.0 to 4.4	Zinc Oxide	65 p. ct.
Hardness	4.6 to 5.0	Carbonic Acid	35 p. ct.

Lustre, vitreous; clearness, translucent; color, gray-white; feel, harsh; elasticity, brittle; cleavage, perfect; fracture, uneven; texture, granular, crystalline.

This ore, like calamine, is often found in the earthy condition, looking more like yellowish-clay than an ore. The miners call both these ores, when in this condition, *tallow clay*, and certain other conditions induce them to call them both *dry bone.*

The silicate and carbonate ores are nearly always found together in veins or beds in the lower groups of the secondary formation, and they are found in the greatest abundance and perfection in the lead mines of Missouri. Like the silicate ores, which go in a pair, one hydrous and the other anhydrous, the carbonates are also two in number, one watered, the other dry. *Hydrozincite* is the wet carbonate, and contains eleven per cent. of water. It accompanies smithsonite, but is unimportant.

ZINCITE.

This is the zinc oxide which appears among the constituents of the silicates and carbonates. Its description is as follows:

Gravity 5.5	Zinc...................80 p. ct.
Hardness 4.3	Oxygen.................20 p. ct.

Lustre, vitreous; clearness, translucent; color, red to orange; feel, harsh; elasticity, brittle; cleavage, perfect; fracture, uneven; texture, granular, foliated.

This is called *red zinc ore*, but it is very rare, and is useful chiefly as an ingredient in the other ores.

GAHNITE.

This is zinc spinel or aluminate of zinc, and, so far as known, it is a very rare ore, but as it may be plentiful, though overlooked, we will describe it:

Gravity 4.3	Zinc Oxide............39 p. ct.
Hardness 7.7	Alumina...............61 p. ct.

Lustre, vitreous; clearness, translucent to opaque; color, green, yellowish or bluish; feel, harsh; elasticity, brittle; cleavage, perfect; fracture, uneven to conchoidal; texture, crystalline.

REMARKS.

Here, again, electricity comes in to use up zinc in primary batteries, and as a diamagnetic coating for paramagnetic iron discs for armature cores, to prevent loss and heating by local currents.

VIII.

NICKEL, COBALT AND CHROME.

NICKEL—PYRRHTITE, MILLERITE, NICKELITE, GLANCE. COBALT—SMALTITE, COBALTITE, COBALT PYRITE, COBALT BLOOM. CHROME — CHROMITE.

NICKEL.

This metal is not found in the metallic form in nature, except as a constituent in meteors along with metallic iron. Its points are:

Gravity	8.2	Nickel	100 p. ct.
Hardness	2.5		

Lustre, bright metallic; clearness, opaque; color, silver-white; feel, smooth; elasticity, flexible; cleavage, none; fracture, hackly; texture, massive.

Nickel is very malleable and ductile, is brilliant and showy, and does not tarnish at ordinary temperatures. It is, therefore, used for cheap coins, spoons, table-ware, and for nickel-plating harness buckles, copper watch cases, and all sorts of sham work. There is no open market for nickel, as its production is monopolized by a few men who keep their own counsel.

PYRRHOTITE.

This is the same *Magnetic Pyrites* which was mentioned as an iron ore and of not much account as such, but it is the ore from which all our nickel comes, so we will describe it again, with an average percentage of nickel in it:

Gravity....................4.5	Nickel................ 5 p. ct.
Hardness...................3.8	Sulphur...............40 p. ct.
Iron.................55 p. ct.	

Lustre, metallic; clearness, opaque; color, yellow to pinkish-yellow; feel, smoothish; elasticity, brittle; cleavage, perfect; fracture, uneven; texture, granular, crystalline.

This ore is a little lighter in color and a little softer than the non-nickeliferous pyrrhotite, but it seems to be fully as magnetic. The percentage of nickel is very various, ranging up to twelve per cent. in rare cases. This is the great ore of the Lancaster Gap mines of Pennsylvania, from which nearly all our nickel supply comes.

MILLERITE.

This is *Nickel Pyrite* or *Sulphide of Nickel*, and it is thought by some that this ore and the ordinary iron pyrrhotite are mixed mechanically and make up the nickeliferous pyrrhotite. However that may be, the description of millerite is as follows:

Gravity....................5.0	Nickel...............64 p. ct.
Hardness...................3.3	Sulphur.............. 36 p. ct.

Lustre, metallic; clearness, opaque; color, yellow to bronze; feel, harsh; elasticity, brittle; cleavage, perfect; fracture, uneven; texture, fibrous, columnar.

This ore is very rich, but it is so scarce as not to amount to much by itself.

NICKELITE.

This is also called copper nickel, from its color, althouga there is no copper in it. Its points are:

Gravity....................7.4	Nickel...............44 p. ct.
Hardness...................5.3	Arsenic ....56 p. ct.

Lustre, metallic; clearness, opaque; color, red to grayish-red; feel, smooth; elasticity, brittle; cleavage, imperfect; fracture, uneven; texture, massive.

This ore resembles the bornite purple ore of copper, but differs as follows: It is a lighter red in color, is one-half heavier, and two-thirds harder than bornite. There are varieties of this ore in which antimony is present in large percentage. This ore also is a rare one, but valuable when found.

GLANCE.

This appears to be nearly the same thing as nickelite, with some sulphur intermixed. Its points are:

Gravity	6.0	Arsenic	45 p. ct.
Hardness	5.5	Sulphur	20 p. ct.
Nickel	35 p. ct.		

Lustre, metallic; clearness, opaque; color, white to gray; feel, harsh; elasticity, brittle; cleavage, perfect; fracture, uneven; texture, cubic, granular, tabular.

There is also a variety of this ore which contains antimony in large percentage, also ruthenium and other rare minerals, but the whole family are hard to find.

Other still more scarce minerals containing nickel are the following: *Nickel Bloom* contains nickel oxide, arsenic oxide and water. *Nickel Emerald* contains nickel oxide, carbonic acid and water. *Genthite* contains nickel oxide, silica, water, magnesia, lime, and is a "job lot" generally. *Grunanite* contains copper, cobalt, nickel, iron, bismuth and sulphur. Ordinary *Iron Pyrite* also often contains a pinch of nickel big enough to be worth looking after, but, as it don't alter the regular descriptive list, it is hard to recognize without a ten dollar analysis.

REMARKS.

Nickel is used for coinage purposes by our government, and it is also the great plating metal next to silver. There is now coming in a new steel, called ferro-nickel, which is claimed to have valuable qualities.

COBALT.

This metal, like chrome, is rarely used in the metallic state, dut its ores furnish us the materials for many of our finest colors, especially those for coloring glass. The beautiful blue smalt is a cobalt color. The following are the ores:

SMALTITE.

This is arsenical cobalt, and its points are:

Gravity	6.5 to 7.0	Cobalt	14 p. ct.
Hardness	5.5 to 6.0	Nickel	6 p. ct.
Arsenic	70 p. ct.	Iron	10 p. ct.

Lustre, metallic; clearness, opaque; color, grayish-white; feel, harsh; elasticity, brittle; cleavage, imperfect; fracture, uneven; texture, granular.

COBALTITE.

This is cobalt glance, and its points are as follows:

Gravity	6.2	Cobalt	35 p. ct.
Hardness	5.5	Sulphur	20 p. ct.
Arsenic	45 p. ct		

Lustre, metallic; clearness, opaque; color, white to reddish-gray; feel, harsh; elasticity, brittle; cleavage, perfect; fracture, uneven; texture, granular to crystalline.

COBALT PYRITE.

This is cobalt sulphide, and its points are as follows:

Gravity	5.0	Cobalt	58 p. ct.
Hardness	5.5	Sulphur	42 p. ct.

Lustre, metallic; clearness, opaque; color, gray to reddish-gray; feel, harsh; elasticity, brittle; cleavage, imperfect; fracture, uneven; texture, granular, fine, or coarse.

In this particular ore the cobalt is more liable to replacement, in whole or in part, by nickel than in any other ore.

COBALT BLOOM.

This is the ore containing oxidized cobalt, and its descriptive list is as follows:

Gravity	3.0	Cobalt Oxide	38 p. ct.
Hardness	2.0	Water	24 p. ct.
Arsenic Oxide	38 p. ct.		

Lustre, pearly to vitreous to dull; clearness, transparent down to sub-translucent; color, crimson-red, bluish to greenish; feel, smooth to harsh; elasticity, brittle to flexible; cleavage, perfect; fracture, mixed even to uneven; texture, foliated, columnar to earthy.

It will be seen that this cobalt oxide is entirely different in appearance and physical characteristics from any of the others. Fine pieces of it form very valuable cabinet specimens.

Cobalt bloom, smaltite and cobalt glance are the ores from which smalt is most usually made. The peculiarity of the cobalt colors is that they stand fire so well, and for porcelain painting, pottery decoration and glass staining they are almost always used.

Cobalt ores never occur in veins or deposits of their own, but they are always found in veins of other metals, such as nickel, copper, and others. These other metals, indeed, frequently replace part of the cobalt in its own ores, so that pure cobalt ore is very rare.

CHROME.

Chromium is the proper name of this metal, while chrome is its ordinary name; but as we are writing for the benefit of the unscientific we will note the fact and go ahead. Chrome is not found naturally in the metallic state, but is entirely derived from its ores. As a metal, it is only used in alloy with iron, making chrome steel for use as a tool steel. It is claimed to be superior to carbon steel for this purpose. It has also been tried for bridge steel, but not successfully.

CHROMITE.

This is the ore from which all chrome is derived. Its descriptive list is as follows:

Gravity....................4.4	Iron Protoxide........32 p. ct.
Hardness....................5.5	Chrome Sesquioxide, 68 p. ct.

Lustre, sub-metallic; clearness, opaque; color, steel-gray to brownish-black; feel, harsh; elasticity, brittle; cleavage, imperfect; fracture, uneven; texture, massive to granular.

The chromite from some deposits looks very like a mass of small duck-shot agglomerated with a yellowish-white cement. Other ore will be of the same analysis, and yet look like the finest-grained magnetic iron ore. These ores are found mostly among the serpentine dykes, and are sometimes in veins, sometimes in pockets, and often distributed through the body of serpentine rocks. The writer has seen beds of sand in which one-half the weight was made up of chromite, this ore having evidently been derived by washing down the substance of neighboring hills.

The uses of chrome are almost entirely connected with the dyeing of fabrics and the making of paints, and for these purposes the ore is acted on directly, without reducing it to the metallic form. Chromate of potash is the brownish-yellow base first produced from the ore, and from this base the bichromates and all the other greens, yellows, blues, browns and reds are produced. The whole business in Europe is in the hands of a Scotch family, and that in America is owned by a Baltimore family, and these two families are in agreement. Many times have new men built expensive works and put new products on the market, but the old manufacturers simply put down prices all over the world, until the new product disappeared from the market. This means the bankruptcy of the new men.

Chrome ore is very apt to have impurities mixed with it, and as its analysis is one of the very difficult ones, its true value is generally known only to the buying agents of these skilled manufacturers. It is also to be remembered that these men constitute the only market for chrome ore, so that mine owners are really at their mercy. The writer has known of sales of ore containing sixty per cent. chromic sesquioxide at forty-two dollars per ton in Baltimore.

Chrome in iron makes chrome steel, much used for cutting tools, but its brittleness and uncertainty are defects.

IX.

ANTIMONY, MERCURY, PLATINUM, &c.

Antimony — Antimony Glance. Mercury — Amalgam, Cinnabar. Platinum. Aluminum. Uranium.

ANTIMONY.

Antimony comes first alphabetically, but not otherwise. It is too brittle to be of much use alone, but it is very valuable in alloys. Journal boxes, type metal, Britannia ware, and innumerable other things contain this metal as a hardening principle. Its description is:

Gravity.....................6.7		Antimony............100 p. ct.
Hardness...................4.0		

Lustre, metallic; clearness, opaque; color white, slightly bluish; feel, harsh; elasticity, brittle; cleavage, imperfect; fracture, uneven; texture, granular.

Antimony sells at from twelve to twenty-five cents per pound, according to purity and state of market. It is only found native in alloy, never alone, and is nearly all obtained from its ores. The peculiar star-like grain or crystalline texture of this metal is enough to furnish its means of identification. It can be easily hammered into powder, being very brittle when pure. It tarnishes very slightly at ordinary temperatures, but when only moderately heated in the open air it oxidizes so rapidly as to give off fumes and flames.

ANTIMONY GLANCE.

This is the great ore of antimony, the others being merely sufficient in quantity to afford cabinet specimens. It is variously called *Gray Antimony*, *Antimonite*, and *Stibnite*, this last being from the former name of the metal, *Stibium*, which is abbreviated into Sb and used as the symbol. The description of this ore is as follows:

Gravity	4.5	Antimony	72 p. ct.
Hardness	2.0	Sulphur	28 p. ct.

Lustre, metallic; clearness, opaque; color, gray; feel, smooth and harsh; elasticity, brittle to sectile; cleavage, perfect; fracture, conchoidal; texture, granular to massive.

This ore tarnishes rapidly, getting black in spots, and sometimes shows a peacock iridescence like bituminous coal. It is very easily melted, and dissolves in hydrochloric acid. It rarely occurs in deposits by itself, its usual companion being the iron carbonates, the zinc, lead and other ores, and the barytic sulphates and carbonates. In California some large veins of mixed ores are found in the foothills of the southern counties, and a considerable supply of antimony is now coming from there. North Carolina is also producing some antimony. This ore sometimes occurs in fibrous texture, looking like bunches of needles.

Antimony is of very great use in the arts to mix with other metals and make such alloys as Babbitt metal.

MERCURY.

Mercury, often called quicksilver, occurs native as little drops and globules among its ores or the rocks containing them. Its description is as follows:

Gravity	13.6	Mercury	100 p. ct.
Hardness	Liquid.		

Lustre, bright metallic; clearness, opaque; color, silver white; feel, greasy; elasticity, cleavage, fracture, all indescribable; texture, liquid.

Mercury is put up in iron flasks, and sells at about forty cents per pound, but the price varies considerably, as there are but few great sources of supply, and their owners sometimes combine to put up their prices. Then they sell all they can for present and future delivery (especially future), get up a quarrel, abuse each other in the papers and drop prices to shake out all the mercury they delivered as "spot." They buy this back from its despairing owners at low prices, and deliver it to fill their contracts for futures.

AMALGAM.

This is mercury which has absorbed silver or other metal, and its descriptive list is as follows:

Gravity	14.0	Mercury	73 p. ct.
Hardness	3.3	Silver	27 p. ct.

Lustre, metallic; clearness, opaque; color, silver white; feel, greasy; elasticity, brittle to sectile; cleavage, none to speak of; texture, granular; fracture, uneven.

This metal varies very greatly in its composition, for it is simply a mixture of molecules and not a chemical compound of atoms. Sometimes gold is found instead of silver, and sometimes gold, silver, copper and other amalgamable metals all together. It is found among the precious metal-mining districts, and although very valuable it is not abundant.

CINNABAR.

This is the great ore of mercury, and its points are:

Gravity	9.0	Mercury	86 p. ct.
Hardness	2.2	Sulphur	14 p. ct.

Lustre, metallic; clearness, opaque to translucent; color, scarlet-red; feel, harsh; elasticity, sectile; cleavage, perfect; fracture, uneven; texture, granular, crystalline

Nearly all mercury comes from this ore, and it is found in beds and veins in the primary and secondary formations It is most abundant among the softer rocks, such as shales, slates, limestones, etc., and least abundant among the harder granites, porphyries, etc. Sometimes it is found permeating the rocks adjoining the veins or beds, and it is fond of companionship with volcanic and sulphurous rocks and beds.

Calomel is mercury chloride, containing eighty-five per cent. of mercury; and *Hydrargyrite* is mercury oxide, containing ninety-two per cent. These two ores accompany cinnabar, but are unimportant.

PLATINUM.

This metal is only found in the metallic condition, sometimes alloyed with other native metals, such as iridium or osmium, but never in chemical combination with other substances which could make an ore out of it.

Gravity	16.0 to 22.0	Platinum	100 p. ct.
Hardness	4.0 to 4.5		

Lustre, metallic; clearness, opaque; color, whitish-gray; feel, smooth; elasticity, ductile, elastic; cleavage, none; fracture, hackly; texture, small, granular.

The specific gravity of platinum is a little mixed, but the trouble seems to be that when in a native state, weighing only sixteen, it is porous, but the pores are so small as to prevent the ingress of water. When it is melted and thoroughly hammered or rolled or drawn, these pores are all closed, and it is so condensed as to weigh twenty-two.

This metal does not dissolve in the acids of usual strength, but when mixed with ten per cent. of silver, nitric acid will dissolve the whole. Platinum is so nearly infusible that it is used by the electricians to concentrate great amounts of electricity in, and when thus charged it becomes incandescent without burning.

Platinum is found in grains and dust in the beds of streams, just as gold is found, and in the same regions, too. Nuggets of ten to fifteen pounds have been found in Brazil and in Siberia. Serpentine rocks and chrome ores are near neighbors of platinum, but it has not yet been found in veins.

ALUMINUM.

Aluminium, or aluminum, as we hasty Americans now call it, is the metallic basis of the aluminous portions of all clays and other such minerals. It is a white metal with a weak bluish tinge, and has a specific gravity of only 2.6, thus weighing about as much as common rocks. The metal has until recently been more of a curiosity than of any practical use, but its production has now passed out of the hands of the professional chemists, who have no time to waste in making money, into those of the manufacturing chemists, who have time for such things, and we are now finding the new metal applied to all sorts of uses, and its price is constantly being cheapened. As showing its greatly reduced price, see the advertisement below:

ALUMINUM, $2 PER POUND.

The Pittsburg Reduction Company, 95 Fifth Avenue, Pittsburg, Pa., U. S. A., offers commercially pure Aluminum at the following rates at Pittsburg, Pa.:

Lots of 1,000 lbs. and over	$2.00 per lb.
Lots of 500 lbs. and over	$2.25 per lb.
Lots of 100 lbs. and over	$2.50 per lb.

Metal guaranteed to be equal in quality to the best metal manufactured by any other process.

And this is not the end of it, either, for there are now several companies in this country making it, and new ones organizing, based on new processes and patents.

URANIUM.

This is a greenish-yellow metal, very heavy, and has heretofore been selling at five to ten dollars per pound, but a heavy vein of an undescribed ore containing it has recently been found in Cornwall, and we may soon see more of it, especially for use by the counterfeiters, for its alloys greatly resemble good gold.

X.

GEMS AND PRECIOUS STONES.

Agate—Alabaster—Amber—Amethyst—Aquamarine—Carnelian—Chrysoberyl—Chrysoprase—Diamond—Emerald—Garnet—Hyacinth—Jasper—Lazulite—Meerschaum—Onyx—Opal—Ruby—Sapphire—Topaz—Tourmaline—Turquoise—Ultramarine—Jade.

AGATE.

This mineral comes first alphabetically, and it is one of the many forms in which silica or quartz occurs. In all civilized countries it is accounted precious, and is cut into gems. Its beauty is much greater than is expressed in the following technical descriptive list:

Gravity 2.6	Silica ....100 p. ct.
Hardness 7.0	

Lustre, vitreous; clearness, translucent to transparent; color, of all kinds; feel, harsh; elasticity, brittle; cleavage, indistinct; fracture, uneven; texture, massive, crystalline.

Agates are built up in nodules, layer upon layer, like the skins of an onion, and in some other cases they look like fibrous wood. Others contain stains of manganese or iron, disposed in moss-like figures and veins, arranged so as to furnish close resemblances to persons and things, which are easily recognized, and these agates command excessive prices. Sometimes the concentric layers in the nodules will be so thin as to be mere films, and hundreds of them occur within the thickness of an inch, while each delicate line can be traced clear around the ball. Agates are carefully cut into finished gems and highly prized in Europe and Asia, but in America no cutters have as yet established themselves, although our rough agates are of the greatest known variety and beauty.

Agates are found, like other quartz pebbles, along water-courses and beaches, but they are generally confined to eruptive or the older primary regions. The great amygdaloid trap rock of the Lake Superior country contains great quantities of agates as amygdules, and as the mother rock disintegrates and washes away, the agates get loose also and find their way down to the stream beds. The same is true of the trap-rock regions of the Rocky mountains, but the trap rocks east of the Appalachian mountains contain very few agates.

The reader is warned that the most beautiful agate, when in a state of nature, looks just like any ordinary water-rolled pebble, and even when roughly broken it shows only indistinctly its peculiar structure. It should never be broken, but should be ground into a small facet on one side, when its structure will discover itself. It is very hard, but can be ground slightly on a smooth quartz stone by hard rubbing. A little oil and some hard, sharp sand will assist the grinding, and the oil will also help in developing the colors quickly.

ALABASTER.

The value of this stone was much greater in ancient times than now. It is used as a material to carve into all sorts of ornamental work for indoor use. It does not stand exposure, and its polish gives way very rapidly before the impure air of our modern dwellings. We keep the smaller carvings of this stone under glass covers nowadays, and we are superseding it with artificial compounds of more real value and fully as great beauty. In former times there were two alabasters, one hard and one soft, but the soft species is now the only one known properly by that name. They were both calcareous, the hard being calcite or calcium carbonate, and will be described with one of the marbles. The soft or true alabaster is calcium sulphate, and its points are as follows:

Gravity	2.3	Sulphur trioxide (acid)	46 p. ct.
Hardness	1.5	Water	21 p. ct.
Lime	33 p. ct.		

Lustre, pearly, sub-vitreous; clearness, opaque to sub-translucent; color, white to delicate pink, yellow or bluish; feel, smooth to harsh; elasticity, brittle; cleavage, imperfect; fracture, uneven; texture, massive, granular.

When thread-like veins of blue or other colors are found in delicate tracery in alabaster the value is increased. This stone is one of the gypsums, and is found in beds in the secondary formation, and in pockets and veins in the primary rocks. There is also a tertiary species of little use.

AMBER.

When you put the amber mouth-piece of your meerschaum pipe between your lips you are tasting some hydro-carbon, but it is not in the same condition as coal tar or corn whiskey; but there is very little difference between the carbon of the amber and that of its counterfeit, celluloid. The descriptive list of amber is as follows:

Gravity	1.0 to 1.1	Hydrogen	10.5 p. ct.
Hardness	2.0 to 2.4	Oxygen	10.5 p. ct.
Carbon	79 p. ct.		

Lustre, resinous; clearness, translucent to transparent; color, yellow, inclining sometimes to red or white; feel, smooth; elasticity, sectile, flexible, elastic; cleavage, none; fracture, uneven; texture, massive, crystalline; tasteless.

Amber is simply a peculiar variety of resin or gum (somewhat similar to the gums used by Yankee school girls for chewing) which has been buried so long as to have become mineralized. It often contains insects which got themselves all stuck up in it while it was still soft, and have floundered around so much that sometimes the wings and bodies are found well separated from each other.

Amber is to be looked for in any of the lignite beds, and also where any fossilized timber is found deep under ground.

Jet is often found with amber, and appears to be the knots of the trees from which the amber gum exuded during the life of the tree.

AMETHYST.

This is one of the quartz stones, but differs from agate in many respects, principally as follows:

Gravity	2.6	Silica	100 p. ct.
Hardness	7.0		

Lustre, vitreous to adamantine; clearness, transparent; color, purple, violet; feel, harsh; elasticity, brittle; cleavage, very indistinct; fracture, uneven; texture, massive.

This crystal comes in six-sided prisms, which generally run to a point at one end, and grow out of a piece of silicious rock at the other. A cluster of amethysts taken out of one "digging" will generally contain crystals of blue, green, yellow, red, gray, and white colors, and these are all called amethysts commonly, although those of purple or violet only are truly entitled to that name. The red crystals are properly called "rose quartz," the clouded ones are "smoky quartz," and the green ones are "prase." The yellow stones are spoken of as false topaz.

The perfectly clear, colorless, limpid crystals are properly called "*rock crystals*," but the ladies have taken them up and made them fashionable under the name of *Alaska diamonds*, and the jewelers are making whole oodles of money out of the fancy. The finest rock crystals in this country are found on Diamond Mountain, near the Arkansas Hot Springs, where they are found in immense number and variety, and of the most ornamental and suggestive forms. That whole country is silicious and the waters are charged with silica.

AQUAMARINE.

This is a lovely stone, and its kinship with the emerald places it in the front rank. This and the emerald are the only two valuable varieties of the *Beryl*, the emerald being the green, and the aquamarine the bluish beryl. The descriptive list is as follows:

Gravity....................2.7	Alumina..............19 p. ct.
Hardness..................7.7	Beryllia (Glucina).....14 p. ct.
Silica.................67 p. ct.	

Lustre, adamantine to vitreous; clearness, transparent; color, greenish-blue; feel, harsh; elasticity, brittle, but tough; cleavage, imperfect; fracture, uneven; texture, granular.

Aquamarines are the perfectly transparent varieties of beryls, the emerald being translucent, and the big, coarse beryl itself being opaque to sub-translucent. There are some yellowish and some whitish varieties which are nearly transparent, but they don't rank with the brilliant-colored blue and green stones as gems.

There is a tendency in aquamarines towards a double refraction power somewhat similar to that possessed by diamonds, but of greatly inferior degree. Aquamarines are very hard, as seen by the point given in the description, and they will cut all the amethysts, but will not cut topaz, and are not acted on by acids. Aquamarines are found scattered in slate rocks, mostly the clay slates of the primary formations.

CARNELIAN.

This is what all the beads are made out of, and it is a member of the chalcedonic branch of the quartz family. Its points are:

Gravity.................... 2.6	Silica................100 p. ct.
Hardness...................7.0	

Lustre, vitreous to resinous; clearness, transparent to translucent; color, various shades of red or flesh color;

feel, smooth; elasticity, brittle; cleavage, none; fracture, uneven to conchoidal; texture, massive, crystalline.

The chalcedonic condition of quartz is a very peculiar one, and has some resemblance to clear wax or resin. There may be large blocks of it, all of massive texture, and without a sign of a cleavage line or surface in it. Flint and hornstone are chalcedonies of the more opaque varieties.

Carnelian colors are not the same in Nature as they are in beads, as the stones out of which the beads are made are first subjected to several days' roasting and some oiling, all of which heightens their tints very greatly.

The operation of making beads is, first, smashing the rock, then rounding each piece by the abrasion produced by rolling half a ton of these fragments in a rolling barrel, then separating them into their several sizes by means of screens, then drilling the holes, then rolling them in smaller barrels to put a polish on them, then boxing up the assorted sizes for sale.

CHRYSOBERYL.

This is one of the aluminous crystals, but is not ranked as high as the sapphires, rubies, and others. Its descriptive list is as follows:

Gravity	3.7	Alumina	80 p. ct.
Hardness	8.5	Glucina (Beryllia)	20 p. ct.

Lustre, vitreous; clearness, transparent to translucent; color, green, in many shades; feel, smooth; elasticity brittle; cleavage, distinct; fracture, uneven to conchoidal; texture, crystalline.

Chrysoberyl is rarely found containing only alumina and beryllia, but there is generally a percentage of both silica and iron, and occasionally a good many other things are mixed in. It is found among the chrysolite rocks along with corundum and the other aluminous stones, and is well worth having, for it is a valued gem. Its great hardness is its ear-mark.

CHRYSOPRASE.

This is another of the forms taken by chalcedonic quartz, and it ranks among the lower grade of gems. Its descriptive list is as follows:

Gravity	2.6	Silica	100 p. ct.
Hardness	7.0		

Lustre, vitreous to resinous; clearness, transparent to translucent; color, apple-green; feel, smooth; elasticity, brittle; cleavage, none; fracture, uneven to conchoidal; texture, crystalline.

This is substantially the same thing as carnelian, but differs in color, owing to the presence of minute amounts of nickel. Some stones of this variety are very beautiful and highly valued.

DIAMOND.

Here we have carbon again, and it is but natural that we should value more highly than any other snbstance this purest form of that greatest mineral which enters so largely into the life, health and comfort of all animated nature, and from whose oxidation is derived all the heat, light and other energies which design, construct and operate all our railroads, steamships, engines, machinery, and everything else worth having in this world. The descriptive list of diamond is as follows:

Gravity	3.5	Carbon	100 p. ct.
Hardness	10.0	Value	1,000 p. ct.

Lustre, adamantine; clearness, transparent; color, colorless to white; feel, smooth and consoling; elasticity, tough, brittle; cleavage, perfect, eminent; fracture, conchoidal; texture, crystalline.

Before going any further we want to state that when a suspected stone is found to agree with the description in the matters of gravity, hardness, lustre, clearness, color, feel and apparent texture, it should be sent to an expert at once, without attempting to apply the tests of elasticity, cleavage and fracture. A diamond will crack and break up like any other pebble, but the cracking will reduce a thousand-dollar diamond into worthless fragments, although the rural wiseacres do say that you can't break a diamond.

The crystal of the diamond is mostly an octahedron, more or less perfect or distorted. A true octahedron is built of two four-sided pyramids joined together, base to base, thus leaving eight triangular-shaped facets exposed. Other crystals take this form also, but the diamond is distinguished from all others by the feature that these facets are always "fulled up" and convex, never flat or concave or hollow. This makes the edges of the diamond crystal rather rounded and blunt, while all other crystals have sharp edges. If a diamond crystal has been broken, one part will show a hollow, fractured surface, while the other part will be convex, fitting into the concavity of the first part.

Diamonds are mostly found imbedded in clay, sand, slate or shale. When found in the sands of gold washings in stream beds, the operation of washing them must be a much more delicate one than gold washing, as the difference in specific gravity is so much less between diamond and quartz than between gold and quartz. There are also many other pebbles than quartz pebbles, and they are often of greater weight than the quartz, so that the probability of losing the diamonds over the edge of the pan, unrecognized, is greater than that of losing gold.

The Brazilian diamonds are found in a stratum of what is called " cement " in California, and which is a mass of pebbles and fragments of pebbles of quartz, mixed with smaller gravels and sands, and all cemented by a red ferruginous clay. This forms layers and deposits on the bed rock of the streams, and often extends out under the bottom lands. In Brazil it contains diamonds, gold, platinum, and many other odds and ends of minerals, but in California it is only worked for gold, while the diamonds, if there are any. get away unseen.

In South Africa diamonds are found in the stream beds of several rivers and their tributaries, and are also found embedded in a mixed-up mess of hardened calcareous clay, pebbles, and all sorts of minerals, which fill up great crater-like cavities in the primary slate beds of the region. The calcareous shale has not only its own proper dose of carbonic acid as part of the carbonate of lime, but there is also a permeation or impregnation of bitumen in the shale, and from these sources of carbon the diamonds appear to have crystallized.

In the United States a few diamonds have been found. Some small ones have been recognized by the gold miners in California, but they have been considered more in the light of a joke than otherwise, and given away, as they interfered with the regular business of gold mining, just as the fisherman threw away his trout, and said that "when he went a catting, he went a catting." Some few small finds of diamonds are also reported in Oregon, Idaho, New Mexico, and Colorado, but so far nothing of much significance has come out of them.

There is a formation of flexible sandstone or quartzite, which ranges from Georgia well up into North Carolina, and which is properly called itacolumite, and it is of the same nature as a stone found near the ferruginous cement of the Brazilian diamond field. There have been some diamonds found here and there along the line of this itacolumite in Georgia and Carolina, and there are good reasons for thinking that proper search would develop an Appalachian diamond field as a little sister to the great coal field of that name There have also been two or three diamonds found on James River, near Richmond, which may have something to do with that vein of natural coke mentioned in the chapter on Coal.

The valuation of diamonds is entirely arbitrary, and depends on many considerations. Among them is the purity or "water" of the stone. If it is perfectly limpid, like a drop of the purest water, it is classed as of the first water.

Then its color comes next, and if it is colorless it ranks highest. The whitish stones rank next; the merest tinge or suspicion of green or blue rather heightens the rank of the white stones. The rose diamond comes next, and after that come the yellow or amber colors, but they must all be perfect in "water" and flawless to rank among the first or royal class. The state of the market is another factor in the price of diamonds. If people are feeling rich and prosperous diamonds are in demand and bring high prices. If people are feeling poor and hard pressed they want no diamonds in theirs, unless they come as testimonials of regard, so to speak, or some other way.

Among diamonds only about one in ten is royal, the others being black, or more or less colored. These inferior stones are called *Bort* or *Carbonites*, and are in great demand to put in as cutters in diamond drills, and to make diamond dust for cutting and polishing. They are not to be despised on account of race or color, as they bring good prices for these uses. Anything that will cut quartz should be looked into.

EMERALD.

The emerald is the translucent or sub-transparent and green variety of the beryl, just as aquamarine is the transparent and blue variety, but the emerald is very much more highly prized than the aquamarine. Emerald is thus described:

Gravity	2.7	Alumina	19 p. ct.
Hardness	7.5	Glucina (Beryllia)	14 p. ct.
Silica	67 p. ct.		

Lustre, adamantine to vitreous; clearness, translucent, sub-transparent; color, rich green; feel, smooth; elasticity, brittle; cleavage, imperfect; fracture, uneven; texture, crystalline.

The coloring of emerald is due to chromic acid in small percentage. Emeralds rank next in value to the diamond, ruby, and finer sapphire. One of four grains is estimated at thirty dollars. Eight-grain stones are worth seventy-five dollars, and sixteen-grain, perfect specimens, have sold at five hundred dollars.

Emeralds are found among the gravels of the rivers and streams in the gold regions, and in pockets in clay slates in the primary formations. A report has been made by a traveling mineralogist that the South American emeralds are contained in lime concretions containing also fossils of Cretaceous age, and he may be right. Emeralds in rocks and pockets are so coated over as to be unrecognizable until tested.

Oriental Emerald is the green sapphire, and is considered very valuable on account of its great rarity as well as its great beauty.

GARNET.

Garnet is nearly a noun of multitude, for there are many garnets. We will describe those coming under the head of precious garnets:

Gravity	4.1	Alumina	21 p. ct.
Hardness	7.0	Iron	43 p. ct.
Silica	36 p. ct.		

Lustre, vitreous, resinous; clearness, transparent; color, red; feel, smoothish; elasticity, brittle and tough; cleavage, distinct; fracture, uneven; texture, crystalline.

This is the precious garnet known to the jewelers, and its value depends altogether on its looks, for it has been known to register itself as a ruby and get sold as such.

There is a large number of other garnets of different composition from the above, and about the only use they are to man is to act as a cutting powder in place of emery. They are pulverized and sold as emery powder extensively.

Garnets are found in all kinds of pockets and veins in any of the primary formations.

HYACINTH.

This is really a garnet, but it sells higher when set on a pedestal of its own, so the jewelers are gradually differentiating it and suppressing all mention of its relationship to garnet. Its points are:

Gravity......................3.6	Alumina...............23 p. ct.
Hardness... ....7.3	Lime...................37 p. ct.
Silica..................40 p. ct.	

Lustre, resinous, vitreous; clearness, transparent; color, yellow, red, brown; feel, smooth; elasticity, tough and brittle; cleavage, imperfect; texture, crystalline.

This stone is also called *Cinnamon Stone*, particularly the brownish varieties. It is found along with other garnets. Another variety of this garnet is called *Ouvarovite*, and is emerald green by reason of the substitution of a little chrome replacing part of the alumina.

There is some reason for the jewelers' attempt to set up hyacinth by itself, because there is another hyacinth, belonging to the tribe of the *Zircons*. It is as follows:

Gravity......................4.6	Silica............. ...33 p. ct.
Hardness....................7.5	Zirconia...............67 p. ct.

Lustre, vitreous, adamantine; clearness, transparent; color, yellow, red, brown; feel, smooth; elasticity, tough and brittle; cleavage, imperfect; fracture, conchoidal; texture, crystalline.

This hyacinth is a little harder and one-fourth heavier than the garnet hyacinth, and its lustre is more brilliant. Altogether, its intrinsic qualities are such as to rank it higher than the garnets, but the market rates it lower.

Zircons and garnets are found often in the same places, and are often mistaken for each other. You can often pick up a hatful of crystals, none bigger than duck-shot, and all of the less valuable kinds, in a stream bed with no good ones.

JASPER.

Jasper is simply quartz tinted with iron oxides, and it rarely amounts to enough importance to be ranked as a precious stone. It has been used as a material with which walls were inlaid in very olden times; and it has been stated, in so-called sacred writings of some nations, that the heavens were made of jasper; but there is something suspicious about the fact that jasper is also the name of the living block of ebonite, in Richmond, which preaches that the "Sun do move." This mineral is getting us into "company," so we will drop it.

LAZULITE.

This is also called *Blue Spar*, and its descriptive list is as follows:

Gravity	3.0	Alumina	34 p. ct.
Hardness	5.5	Magnesia	13 p. ct.
Phosphoric Acid	47 p. ct.	Water	6 p. ct.

Lustre, vitreous; clearness, translucent; color, deep-blue; feel, smooth; elasticity, brittle; cleavage, slight; fracture, uneven; texture, massive, crystalline.

Like all other minerals, this has its fine and coarse varieties, the fine ones being valued, more or less, for jewelers' purposes; and the coarser ones, when plentiful, being in some demand as sources of phosphoric acid.

Lazulites are found among the primary rocks, especially among the slates.

MEERSCHAUM.

Of course the ornamental sex will object to our classing this among precious stones, and will repeat their standing joke about meerschaum being mere sham, and all that, but we, knowing its extreme preciosity, can smile grandly at their ignorance of true value, and preserve our equilibrium of unruffled peace of mind by re-lighting our pipe. Here is what it is made of. Hydrous silicate of magnesia:

Gravity	0.8	Magnesia	27 p. ct.
Hardness	2.0	Water	12 p. ct.
Silica	61 p. ct.		

Lustre, refined earthy; clearness, opaque; color, that of rich, delicate cream; feel, smooth; elasticity, brittle to sectile; cleavage, none; fracture, flat to conchoidal; texture, superfinely massive.

The few chemists who are not smokers have had the temerity to name this mineral *Sepiolite*, but they are only postponing their day of smoking. The word meerschaum means sea foam, and the mineral was so named because it was first found floating as sea foam on the coasts of Turkey, where the surf washed against a bank of the pure mineral itself and washed it into the sea. Being lighter than water, it floated and ground itself into a foam-like consistence. The Turks gathered and compressed it and carved it into pipe bowls, and with their usual sagacity they avoided the rock bed of the mineral, and declared it was hardened sea foam.

For some occult reason Providence has tolerated the existence at various times of men who have devoted their time and so-called brains to the manufacture of an artificial meerschaum, but they have uniformly met with such failure as they deserved. One fiend, in New York, tried to produce a pure silicate of magnesia, cementing tripoli, after Ransome's artificial stone fashion of cementing sand or marble dust, by means of a true silicate of lime. He mixed tripoli with silicate of soda and modeled it into pipe bowls, then bathed it in chloride of magnesia to effect a double decomposition, intending to wash out the resulting chloride of sodium, but somehow he failed to connect.

Meerschaum is to be looked for among the talcose rocks, as these are allied mineral species—magnesium silicates. Meerschaum is undoubtedly derived from them, but how it got to be so very light and with such minute pores all through it is one of those things "no fellow has found it." This excessive lightness and porosity constitute the chief portion of its value, and secures it against any successful attempt to counterfeit it.

Meerschaum has a number of cousins, but they are all "poor relations." *Aphrodite* is the best of the lot; *Smectite* is another. *Chloropal* is a greenish species, but none of them come up to the true mineral in its specialties. Hunt for it.

ONYX.

Onyx is quartz in the chalcedonic condition, and is constructed in films and layers of different colors, like agate, but these films in onyx are laid down flat, whereas in agate they are in consecutive skins, like the peelings of an onion. The gravity, hardness, composition, etc., of onyx are the same as those of agate, and we will not repeat them.

The value of onyx is in the fact that its films of color are so thin that it can be cut in cameo, portions of the figure being of one film and color, while other portions are cut through to deeper films and colors. The choice colors in true onyx are white, black and brown, while a variety called *Sardonyx* has also a film of carnelian red.

OPAL.

This is quartz also, but it has some water in it, which produces decided results in decreasing weight and hardness, and otherwise. Its descriptive list is as follows:

Gravity	2.2	Silica	85 to 97 p. ct.
Hardness	6.0	Water	15 to 3 p. ct.

Lustre, vitreous, pearly, opaline; clearness, transparent; color, white, pale, yellow, gray, green, red; feel, smooth; elasticity, brittle; cleavage, imperfect; fracture, even to conchoidal; texture, massive, crystalline.

The peculiarity upon which the value of opal chiefly depends is its power of exhibiting a wonderful play of colors as it is turned to various angles with the light. The most remarkable is the *Fire Opal*, which displays all the colors of fire-works in successive flashes when turned. *Precious Opal* seems to be the very finest and most delicately shaded and tinted of the fire opals. Like chalcedonic quartz, this hydrous quartz has its agate-formed stone also. It is made up of concentric films and layers of various colored opal, and is called *Opal Agate;* the well-known cat's eye is one of these.

There is a *Jasper Opal* which is reddish and of not much value or beauty, and there is *Float Stone*, made up of opal in a very porous condition, looking much like a lustrous pumice stone, and so ligh as to float on water. The shells of the diatoms and other silicious infusoria seem to be of silica in the opaline condition, and for this reason tripoli is not hard enough to do much in polishing quartz crystals.

The silicious deposits around what are called petrifying springs are of opaline quartz, and wood thus petrified becomes wood opal.

Opal is found almost anywhere that quartz is found, but the valuable opals are very scarce. Some are occasionally found among the tripoli beds, and they have been found in cavities in limestone, just as flint is so found.

RUBY.

There are two kinds of ruby, both of great value as gems. These are the *Spinel Ruby* and the sapphire ruby, and we will first describe the spinel, as follows:

Gravity	3.5	Magnesia	12 p. ct.
Hardness	8.0	Chromic Acid	3 p. ct.
Alumina	85 p. ct.		

Lustre, splendent, vitreous; clearness, transparent; color, light, medium or dark-red; feel, smooth; elasticity, tough but brittle; cleavage, perfect; fracture, conchoidal; texture, crystalline and octahedral, with points and edges cut off square, or nearly so.

This ruby is found generally in localities where serpentine and marbles or other limestones are the country rocks, and it is often found among the water-worn pebbles in the stream beds.

The *Sapphire Ruby* is described as follows:

Gravity	4.0	Alumina	100 p. ct.
Hardness	9.0	Chromic Acid	trace.

Lustre, splendent, vitreous; clearness, transparent; color, light, medium or dark-red; feel, smooth; elasticity, tough, brittle; cleavage, perfect; fracture, conchoidal; texture, crystalline, hexagonal.

This and all other sapphires are pure crystalline corundum, with a tinge of some coloring matter thrown in. The spinel and sapphire, or *Oriental Ruby*, as it is called, are difficult to distinguish from each other. The item of hardness affords the best test short of a chemical analysis, as the weight of the spinel often varies by reason of the presence of iron. The beauty of the stone is what names the price regardless of the constituents, unless the parties have prejudices in favor of either spinel or oriental. As a general thing, oriental stones are most valuable, and spinel of equal beauty is handicapped by reputation.

Oriental rubies of the very finest qualities are more valuable than diamonds of the same weight. The English prices for cut stones are about eighty dollars for a one-carat stone, three hundred and sixty dollars for two carats, eleven to twelve hundred dollars for three carats, two thousand for four carat stones, and so on. This stone is to be looked for in the stream beds and other places wherever corundum or emery occur.

SAPPHIRE.

These stones come in many colors from Nature's laboratory, but the one labeled sapphire in the jewelers' vernacular is as follows:

Gravity	4.0	Alumina	100 p. ct.
Hardness	9.0	Cobalt	trace.

Lustre, vitreous, splendent; clearness, transparent; color, azure, celestial, etc., blue; feel, smooth; elasticity, tough but brittle; cleavage, perfect; fracture, conchoidal; texture, cyrstalline, crystals, hexagonal or double hex.

Sapphires are to be looked for in the same localities as ruby, corundum and emery. Neither ruby nor any of the other kinds of sapphire are very attractive in appearance when found wild, and when suspiciously heavy pebbles are picked up they should always be tried to see whether they will scratch a piece of quartz crystal. If they do so, they should be preserved and sent to a chemist or reliable jeweler for examination.

Sapphires of most celestial hue and all the other good qualities are only worth about one-fourth as much as the oriental rubies of same size, but still they are worth picking up. At a recent meeting of a scientific asssociation, in Berlin, an escort of soldiers brought in for exhibition a sapphire, which, according to the scales and rules of estimation, was worth sixteen millions of dollars. It weighed fifteen ounces, and was declared to be at least a "prince's ransom," by some enthusiastic royalist. There were other members of the association who thought that any nation which would pay sixteen millions of dollars for either an ornamental stone or an ornamental prince had better spend all the rest of their money in lunatic asylums. Another member thought the sixteen millions was a small price to pay for getting rid of some kings and princes he knew of.

Yellow sapphires are called *Oriental Topaz*, green ones *Oriental Emerald*, and violet ones *Oriental Amethyst*.

TOPAZ.

Topaz is described as follows:

Gravity	3.5	Aluminum	30 p. ct.
Hardness	8.0	Fluorine	20 p. ct.
Silicon	15 p. ct.	Oxygen	35 p. ct.

Lustre, vitreous, splendent; clearness, transparent; color, yellow; feel, smooth; elasticity, brittle, tough; cleavage, perfect; fracture, uneven; texture, crystalline.

This is the precious topaz. There are other varieties which are colored greenish, bluish or reddish, and some even are perfectly colorless. When these various colors are in stones that are entirely transparent and otherwise perfect they have a high value also, for they are sold as rubies, sapphires and diamonds to the inexperienced, who too often rely on their own judgment and buy things on their good looks.

The great trouble with topaz is that it is generally clouded and only translucent, so that it can only be used in the manufacture of polishing powders. It is the same hardness as spinel ruby and will cut all quartz crystals.

Topaz changes color under a moderate application of heat, and thus changes in its value can be brought about. The clear yellow quartz is sometimes called *False Topaz*, and yellow sapphires are *Oriental Topaz.* Topaz is found in the primary formations, especially among micaceous rocks and in the stream beds of micaceous districts.

TOURMALINE.

Tourmaline in some of its varieties is valued as a gem, and is described as follows:

Gravity	3.1	Boric Acid	10 p. ct.
Hardness	7.3	Iron Oxide	8 p. ct.
Silica	35 p. ct.	Magnesia	5 p. ct.
Alumina	35 p. ct.	Water, Lithia, etc.	7 p. ct.

Lustre, vitreous; clearness, transparent; color, yellow, red, green, blue; feel, smooth; elasticity, brittle; cleavage, not perfect; fracture, uneven; texture, crystalline, in crystals of three, six, nine and twelve sides—always a multiple of three.

The clear, rich-colored stones are valued highly. The red is called *Rubellite*, and is often passed off for ruby. The yellow is sold for topaz, and some amber and honey-colored yellow tourmalines are among the most beautiful gems in existence. Black and blue tourmalines in long, slender three-sided crystals bring good prices as cabinet specimens.

Tourmaline becomes electric when heated, and the transparent crystals have the property of polarizing light. It is found in the primary formations among the more micaceous rocks and slates, and among the crystalline limestones and dolomites. Sometimes a mass of rock, several pounds in weight, will have forty or fifty spikes of black tourmaline passing through it in parallel lines.

TURQUOISE.

This mineral is described as follows:

Gravity	2.7	Phosphoric Acid	33 p. ct.
Hardness	6.0	Water	20 p. ct.
Alumina	47 p. ct.		

Lustre, resinous; clearness, opaque; color, blue-green; feel, smooth; elasticity, brittle; cleavage, none; fracture, sub-conchoidal; texture, crystalline.

This stone is found with kaolin and other highly-aluminous clays, and with the clay slates and shales of the primary formations. It is generally decomposed on the outside, and looks like a lump of kaolin. Veins containing much aluminous mineral, as gangue rock, are the best prospect. The old Aztecs valued this gem very highly, and got it mostly from New Mexico, where their old pits are now being reopened. The Old World is supplied with turquoise from mines in Southeast Persia, worked for thousands of years.

ULTRAMARINE.

This is also called *Lapis Lazuli*, and its points are:

Gravity	2.5	Alumina	32 p. ct.
Hardness	5.8	Soda and Lime	15 p. ct.
Silica	45 p. ct.	Sulphur, Iron, etc.	8 p. ct.

Lustre, vitreous; clearness, translucent; color, bright blue to green; feel, smooth; elasticity, brittle; cleavage, distinct; fracture, conchoidal; texture, granular, crystalline.

This is a much-valued gem, and is used in brooches and other ornaments which are of such shape as to utilize slab-shaped blocks. It is also used for all sorts of expensive inlaid work in mosaics and the finest ornamental carvings. This mineral is to be looked for among the granites and other primary rocks, particularly the marbles. It also occurs among the limestones of the lower secondaries.

It takes its name from the lovely blue color of the paint which is made by pulverizing and triturating selected pieces of this mineral. Ultramarine ranks higher with the artists than aquamarine as a color, but aquamarine is the most valuable as a gem.

JADE.

This is nephrite or kidney stone, and after it is carved by the Chinese and other Pagans into images of Beelzebub, and other mighty personages, it becomes a precious stone. Its points are:

Gravity......................3.0	Magnesia..............30 p. ct.
Hardness....................6.3	Lime..................15 p. ct.
Silica..................55 p. ct.	

Lustre, vitreous, glistening; clearness, semi-translucent to opaque; color, white to gray, tinged with blue or green; feel, smooth; elasticity, brittle to tough; cleavage, imperfect; fracture, uneven, splintery; texture, compact, massive.

This is a silicate of lime and magnesia, and is a member of the hornblende series. It is found in slabs or chunks among the hornblendic rocks, talcose slates, &c., and is well worth collecting for carving purposes, cabinet specimens, &c.

XI.

ORNAMENTAL AND BUILDING STONES.

SERPENTINE — MALACHITE — MEXICAN ONYX — MARBLE — LIMESTONE — SANDSTONE — SLATE — GRANITE — SYENITE — GNEISS — PORPHYRY.

SERPENTINE.

Other members of this group are *Bastite*, *Cerolite*, *Gymmite*, *Marmolite*. The points on serpentine are:

Gravity	2.5 to 2.8	Magnesia	43 p. ct.
Hardness	3.0 to 3.7	Water	13 p. ct.
Silica	44 p. ct.		

Lustre, pearly; clearness, translucent to opaque; color, green; feel, smooth to harsh; elasticity, flexible to brittle; cleavage, imperfect; fracture, uneven; texture, granular. Serpentine is very abundant among the primary rocks, and amounts to an eruptive rock all by itself, showing in dykes and round-backed ridges and hills. It is much in favor as a fancy building stone, and properly handled it produces very fine architectural effect. When very bright green and capable of taking high polish it is much used for mantels and other interior work, and is called "precious" serpentine. When it is streaked with magnesian marble it is called "Verde Antique," and will be referred to further along in this book.

MALACHITE.

This is copper carbonate, and its descriptive list is as follows:

Gravity..........3.9	Carbonic Acid..........20 p. ct.
Hardness..........3.8	Water.......... 8 p. ct.
Copper Oxide..........72 p. ct.	

Lustre, vitreous, adamantine; clearness, translucent; color, green; feel, smooth; elasticity, brittle; cleavage, perfect; fracture, conchoidal, uneven; texture, massive, crystalline.

This is always found with the other copper ores, and when it is not sufficiently brilliant and rich in coloring and figure to be used as a gem, or as a material for inlaid work, or for table-tops, Chinese vases or devils or other devices, it is not a loss by any means, for it is a most valuable ore of copper. The green color has an oily look about it, and is very much broken up into rounded figures, giving a pleasing variety. Perfect malachite, capable of being cut into slabs, is very valuable.

There is a blue variety of this mineral which is usually called *Azurite* and contains a few per cent. less copper and water, and a few more of carbonic acid. It is generally found as an associate of malachite, and when perfect in color, figure and brilliancy, it is fully as valuable. These ores are to be hunted for among any or all copper-bearing rocks, and are nearly always associated with other copper ores.

MEXICAN ONYX.

This is not a true onyx, as this is calcium carbonate, and onyx is silica or quartz. The descriptive list of Mexican onyx is as follows:

Gravity..........2 8	Lime..........56 p. ct.
Hardness..........3.0	Carbonic Acid..........44 p. ct.

Lustre, vitreous to waxy; clearness, translucent; color, greenish-white, permeated with veins of all colors; feel, harsh; elasticity, brittle; cleavage, perfect; fracture, conchoidal; texture, massive, crystalline.

This stone is a deposition of calcite, mixed with impurities, from the water of limestone springs or streams or lakes. As mentioned among marbles, the stalagmites and stalactites of wet caverns are examples of this deposition in crystalline form, and the writer has had carved lovely paper weights, inkstands and pipe bowls from selected stalactite materials.

The veins and their fibres found in the stone are due to dust or other colored substance getting on the surface of the growing stone, either through accidental deposit, or by solution of iron or other coloring mineral in the rocks above getting into the limestone water. The stone is found in Mexico and in many other places in such position as to indicate that it was the precipitation of calcite out of the calm waters of a lake. Other deposits are in fissures or veins or caves in limestone rocks, which fissures, etc., have been filled thus in past ages.

MARBLE.

There are two principal marbles, and one intermediate between these two. These are: the lime marble composed of the mineral *Calcite*, the magnesian marble composed of the mineral *Magnesite*, and the intermediate and most common marble composed of the mineral *Dolomite.* The description of calcite is as follows:

Gravity	2.5 to 2.8	Lime	56 p. ct.
Hardness	2.7 to 3.3	Carbonic Acid	44 p. ct.

Lustre, sub-vitreous; clearness, translucent; color, white; feel, meagre to rough; elasticity, brittle; cleavage, perfect; fracture, conchoidal; texture, crystalline, granular.

This mineral is the basis of all the lime, marbles, chalks, marls and limestones. The only reasons that these are not all clearly defined crystals are that they contain impurities which render them more or less opaque, and that they were deposited in such small particles that they appear earthy in texture, although the particles generally are seen under the microscope to be crystalline when not in the form of shells.

The mineral magnesite is as follows:

Gravity	2.9 to 3.3	Magnesia	47 p. ct.
Hardness	3.7 to 4.4	Carbonic Acid	53 p. ct.

Lustre, vitreous; clearness, translucent; color, white; feel, roughish; elasticity, brittle; cleavage, perfect; fracture, conchoidal; texture, granular, crystalline.

This mineral is ten per cent. heavier than calcite, and thirty per cent. harder. Another point of difference is that magnesite does not rapidly effervesce when touched by cold nitric or sulphuric acid, while calcite fumes and bubbles actively.

Dolomite is described as follows:

Gravity	2.9	Calcite	54 p. ct.
Hardness	3.7	Magnesite	46 p. ct.

Lustre, vitreous; clearness, translucent; color, white; feel, rough; elasticity, brittle; cleavage, perfect, fracture, conchoidal; texture, granular, crystalline.

When any or all of these three minerals are found greenish, yellowish, bluish, reddish, or any other color than white or colorless, it is because of the presence of coloring matter which is an impurity, strictly speaking. There are very many methods or forms of crystallization, but none of them change the color of the *pure* mineral.

Sometimes calcite is found nearly as clear and colorless as the finest diamond, and in this state it is called *Iceland Spar* when in tabular blocks, or *Dog Tooth Spar* when in sharp-pointed double-ended crystals. When it is in long slender fibres in bunches it is called *Satin Spar*.

Stalagmite is the material deposited on the floors of caverns by the crystallization of calcite out of limestone waters dripping from above, and *Stalactite* is the spike or point from which the water drips. These forms are just like the icicles at the top and bottom of a water-drip in freezing weather.

Sometimes these stalactites and stalagmites continue to grow until they meet and form columns shaped like hour glasses, at first, but which gradually fill out until they join up with their neighbors and fill the cavern or fissure entirely.

The above are the materials of which the marbles are made. They make up differently as regards structure, however. The pure calcite makes a fine-grained white marble of great purity but no variety. *Parian* marble is composed of minute foliations or scales, which are so irregularly placed as to seem under the microscope the veriest case of toss and confusion that could be imagined, yet the scales are so small that it feels smooth as glass when polished. *Carrara* marble is in minute flattened grains, placed criss-cross and every which way, but no one would suspect it when looking at the exquisite surface of the finest statuary made from that stone.

Dolomitic marble is more translucent than calcite marble, but the grains and crystals are much larger, and appear to be star-rayed. This marble also loses its uniform surface sooner than the other, and becomes rough and weather-beaten. The calcite marble, however, tarnishes and stains more rapidly than the dolomite.

There are black marbles also, and some of these have white and red and other colored veins traversing them, but they are so easily counterfeited by what is called marbleized iron or slate that they are going out of fashion. There is a fine black marble in Georgia and Alabama.

Breccia is a stone made up of angular fragments of marble embedded in a cement of the same material; and variegated marble is the same thing except that the fragments are rounded instead of being angular. The coloring of the fragments and the cement of course vary very greatly. We have very fine beds of these marbles in East Tennessee, and in Maryland, near Washington, called calico stone.

Verde Antique is a mixture of marble and serpentine, the magnesian marble being most frequently found in this connection, as the serpentine is a magnesian mineral also. The white or red or brownish marble alternates in veins and coils and rosettes with the brilliant green of the serpentine in most exquisite fashion, and this stone is very highly valued for inlaid and other ornamental work for interior fittings.

Lithographic Stone is an excessively fine-grained, subtranslucent, slate-colored or yellowish marble that is nearly a limestone. The finer varieties of oolite and other fossiliferous limestones are often polished and used in place of the real crystalline marbles.

LIMESTONE.

This is simply the re-deposited debris of the marbles of the primary formation supplemented by the work of marine animals and vegetables of the secondary ages. It is probable that those beds in which the most fossils are found are the ones formed by the slow building of the infusoria during secondary times, while those of larger grain and fewer fossils may have been made of materials derived from washing down the primary marbles. This latter material is most apt to be deposited near the shore line of the ancient seas, and to have sand and clays mixed with it; while the limestone of secondary age would be formed in deep, still water, and would thus be of finest grain unmixed with anything but fossils.

The limestone known as oolite, composed of fish eggs about the size of small homeopathic globules, is one of the most valuable building stones we have.

SANDSTONE.

This is derived from the primary quartzite which has been washed down and deposited in new beds during secondary times, and became hardened by time and pressure. The sandstones are found in beds all the way up, at intervals, throughout the whole secondary series, and the sands constitute at least three-fourths of all the mass of materials in this formation. The principal differences to be seen among the beds are variations in size of grain. There are four great plates of sandstone between the top of the primaries and the bottom of the great coal measures. The Potsdam sandstone lies on the primaries and forms the crest and western slope of the Blue Ridge. The Medina sandstone is the second, and forms the crest and western slope of North Mountain. The Oriskany is the third great sandstone, and forms the crest and western slope of Capon Mountain and others on that line of upheaval. The Millstone Grit is the fourth great sandstone, and forms the base of the coal measures. The Mahoning sandstone is the plate that divides the coal measures into upper and lower coals.

The secondary rocks extend westward beyond the Mississippi to the Rocky mountains, broken, of course, where the before-named primary upheavals come up through, but the further west they extend the thinner they get. Rock beds which are hundreds of feet thick in the Appalachian mountains are represented in Missouri by feather-edged beds of but few feet in thickness, while at the foot of the Rockies many of the beds are missing altogether.

There are detached areas of secondary rocks east of the Blue Ridge, which, although small, are of great value, for these areas furnish all the brown-stone used in building in New York and other cities in the Eastern States. The stone comes from the triassic beds of the secondaries, which are found in troughs in the primary rocks all the way from Nova Scotia down to Georgia, the beds, however, not being continuous. The northern slope of Nova Scotia is of this triassic age. Shaler's quarries, in Connecticut, furnish nearly all of this stone used in Boston, Providence, New York, New Haven and Hartford. The red soils of New Jersey are underlaid with it. Parts of the Susquehanna, near York, and all the Monocacy Valley are of this formation The Grant-Seneca quarries are in this, and the Virginia Midland railroad runs across many miles of it. The gray sandstones in which the Richmond coals are found are of this age. The Deep River and Dan River coals of North Carolina are in these rocks, and this writer thinks he has identified them in South Carolina and in Georgia at several points.

The red sandstone of the Seneca (Potomac) quarries is now the fashionable stone, and its great beauty and durabilty fully justify its popularity. The great sandstones used in the West are typified by the Amherst and Berea blocks of the Cleveland Stone Company, which analyze as below:

Amherst Stone.		Berea Stone.	
Silica	97.00 p. ct.	Silica	97.00 p. ct.
Lime, Magnesia, &c.	1.60 p. ct.	Lime, Magnesia, &c.	1.20 p. ct.
Iron Oxides	1.00 p. ct.	Iron Oxides	1.50 p. ct.
Moisture	.40 p. ct.	Moisture	.30 p. ct.

QUARTZITE.

This is the sandstone of the primary formation, and is composed of the silica washed out of such silicated ternary minerals as have decomposed. It is the same as the sandstone of the secondary and later formations, except that it is composed of more perfectly crystalline grains and has fewer impurities mixed with it. A variety called *Itacolumite*, or "elastic sandstone," has the grains and the connecting cement arranged in ball-and-socket fashion, and sometimes with small grains of mica scattered through it. This gives it a certain flexibility; but as it does not spring back of its own accord, it ought not to be spoken of as elastic. It is the best natural stone for "inwalls" of furnaces, as its peculiar structure prevents expansion or contraction, the open joints taking or giving all the slack either way.

SLATES.

These are the finest of the stratified laminated rocks, the grains being rather more flat than round, and they are always laid down flat, thus giving a laminated structure to the slate. There are three slates among the primary rocks, the bottom one, resting on the schists or gneiss, being the micaceous slate; the second, the talcose slate; and the third, the chlorite slates. The whole three, together with the clay shale next spoken of, are the great gold-bearing rocks of the world. The mica slates are blue or gray, specked with minute particles of mica, the talcose and chlorites being greenish, the chlorite being the cleanest and brightest green. The talcose slate is the most auriferous and feels greasy.

From Buckingham county, Virginia, now comes a slate from which lovely sills, lintels, steps, &c., are cut. The great roofing slates of Pennsylvania come from the Utica and Hudson shales, and the Delta, Md., slates are in Parr's Ridge among the primary rocks. The North River bluestone flags come in the Hamilton group.

GRANITE.

Granite is built up of well-regulated crystals of feldspar, quartz and mica, and it is called granite because it is so perfectly granular. The quartz is generally white; the feldspar white or pinkish, and the mica is usually lead-colored, but often dark-brown or even black, and gives ruling color to the mass, except in the red or Scotch granite, where the color is due to red feldspar.

SYENITE.

This is hornblende granite, the hornblende being in place of mica in the true granite. It is more apt to be darker in color and considerably finer in grain than the micaceous granite. It is found in great sheets and masses like granite. This stone is the Egyptian black granite.

PROTOGENE.

This is talcose granite, the talc replacing the mica in this stone, just as hornblende replaces it in syenite. It is, of course, granular, and occurs in great sheets and masses. The substitution of talc for mica gives it a slightly greenish tinge.

These three granites are often confused, or taken for each other. Some granites are much harder than others, and, for a while, it was thought that hard granites made the best block pavements; but the softer granites are now coming in again, as it is found that they don't wear smooth to a polish, and horses don't slip on them.

The granites split in the rift and in the grain with almost equal facility, and they can be very finely carved and highly polished, and would be the most useful stones known if they could stand fire.

GNEISS.

This is made up of any of the minerals contained in the foregoing granular rocks, but when gneiss contains mica it does not often contain either talc or hornblende. When containing hornblende it generally omits mica and talc. When talc is present mica and hornblende are mostly absent. This shows that gneiss is either washed down granite, syenite or protogene, or else the granites are melted gneiss. The gneiss is evidently a sedimentary rock, as it is coarsely and irregularly stratified, and there are reasons for holding that it is part of the original sedimentary rocks scalped off in the earliest days.

Gneiss fades upwards into the finer-grained and more perfectly stratified schists; downward into the highly crystalline, granular granite rocks, and horizontally it fades into granite also. There are cases where granite rocks rest on top of gneiss, separated therefrom by a sharp line of contact, which shows that the granite overflowed the gneiss in a sheet or stream from some neighboring fissure. Other cases show the gneiss on top of the granites with equally sharp line of contact, which shows that there had been a second sedimentary deposit on top of the granite formed by the melting of a former bed of gneiss. Still other cases show the gneiss fading downwards and laterally also gradually into granite, which show that the second heating up was not sufficiently intense to melt up the whole mass of gneiss.

The great quarries at Port Deposit are in this stone, and for heavy construction, such as bridge and railroad masonry, and sub-walls of all sorts, gneiss is just what is wanted, as it is well bedded and quarries easily.

PORPHYRY.

True porphyry is composed entirely of feldspar, the arrangement being a number of large crystals of feldspar embedded in a cement of the same material. It is an agglomerate, whereas it is often the case that conglomerates are called porphyry by men who ought to learn better. The *agglomerates* are those in which the pebbles and the cement are the same materials, while in *conglomerates* they are of different materials.

The ancients used porphyry and jasper for interior work, but the capitol buildings of our new State of Montana, at Helena, are built throughout of this stone, and are said to be ahead of even the red granite capitol buildings just built in Texas.

XII.

CEMENTS AND CLAYS.

Natural Cements—Portland—Roman—Rosendale—Selenite. Brick Clay—Potter's Clay—Fire Clay—Kaolin—Bauxite—Dinas.

CEMENT.

The simplest form of cement is lime, which is calcium oxide, and is produced by burning the carbonic acid out of limestone or marl or chalk or oyster shells, etc. The residue is lime, and is a white alkaline earth, very caustic. This lime, when exposed to dry air, will not re-absorb the carbonic acid out of the air; but, as natural air is never dry, the lime absorbs first the moisture and then the carbonic acid, and, in time, it returns to its original condition of limestone, etc.

Builders take advantage of this by mixing sand or other granulated substance with lime, and putting in water enough to make a stiff paste. They use this paste for a cement or mortar between their bricks or stones, and when the lime takes up carbonic acid out of the air it "sets" and hardens, and binds the bricks or stones into one wall. It is evident that if this lime-cement or mortar be placed under water, the air cannot get to it, and the lime can find hardly any carbonic acid to absorb; but, nevertheless, ordinary lime mortars will harden under water if they have time enough, and are protected against any disturbance or washouts by currents, etc.

This fact shows that there is some other chemical action at work not dependent on exposure to air. This action was found to be silicification, or the action of the acid silica upon the alkaline base, lime, whereby a true silicate of lime was produced, and this was found to be a stronger cementing factor than the carbonate of lime.

This is the starting point for Ransome's artificial stone. Ransome mixed selected sand with silicate of soda, and molded the stiff paste into blocks, then drenched the blocks with solution of chloride of lime. A double decomposition took place within the body of the block, the chlorine taking the soda for a partner, and the silica joining the lime as silicate of lime. The sodium chloride (common salt) was afterwards washed out with water, leaving a solid block of sand cemented by silicate of lime. Very handsome molded blocks, of many colors and textures, were formed by mixing in proper substances.

In lime mortar, the silicic acid comes from the clean, sharp sand, and is very slow in laying hold of the lime. To quicken the silicifying action, selected clay, containing silica and alumina in the finest state of pulverization, was used to relieve the coarser sand, and the silicate of lime formed very rapidly around the sand. The alumina in the clay was also found to form still another cementing substance, but slower in its action, viz.: the aluminate of lime. While mortars rely principally on the carbonate of lime, cements rely on the silicate of lime for quick setting, and the aluminate of lime for slow setting.

It resulted from all this research that henceforth all first-class cements must have the three substances, lime, silica and alumina; but, as clay generally contains both alumina and silica, the cement-makers confined themselves to securing either a native stone which should combine the substances in proper proportion, or else to securing the substances themselves and combining them.

It is customary to consider that Nature does things better than man does them, but the persons who hold this opinion do not reflect that man is merely one of Nature's fingers or instruments, and that as he is the latest and most improved instrument, so he should be expected to turn out better results than any of his predecessors. Even so it is in cements. The forces which piled up lime, silica and alumina in beds which are now hardened argillaceous limestones did their work without knowledge of what was wanted, but man knows more about it, and so he puts in the proper proportions of each substance.

The native limestones are used by most of the cement-makers of this country, as it so happens that we have rocks here which are much more nearly just the proper composition than those available for the purpose in England. The localities where these argillaceous limestones are found in this country are very numerous, and will not be mentioned here, as almost any district among the secondary rocks will supply them. The general proportions of the substances in these rocks should pretty nearly agree with the analysis of Portland cement as given below, because, otherwise, the party who puts his money into the venture is putting it in peril. There is, however, considerable leeway around these proportions, for a cement that bears on the aluminates as its chief factor, although a slow-setting cement, is often better for certain purposes than the cement which counts on its silicates. The Portland cement, celebrated the world over, is made normally with an equilibrium between the silicates and aluminates, and the makers vary it for special orders only.

The composition of normal Portland cement is about as follows:

Lime	60 p. ct.	Alumina	8 p. ct.
Silica	25 p. ct.	Impurities	7 p. ct.

The impurities are generally made up of iron oxide, magnesia, gypsum, potash, soda, and other trash.

The best Portland cement-makers grind together selected chalk and clay with water, then make the pulp into balls and burn them at a white heat for several days. Then the calcined balls are ground to impalpable powder and packed in barrels lined with prepared paper.

The old Roman cements differed from each other as much as ours do, but they all contained a large percentage of iron oxide. An average is as follows:

Lime....................55 p. ct.	Alumina............... 7 p. ct.
Silica..................22 p. ct.	Iron Oxide............12 p. ct.

Together with four per cent. of impurities.

There is a large class of very good but slow-setting cements in this country which contain magnesia along with lime as the alkaline basis of the silicate and aluminate compounds. The cements called "Rosendale" are of this class. These magnesian cements, when properly treated in all respects, make one of the very best cement joints attainable, but great care must be taken to preserve them, in storage or transportation, against access of moisture.

There is still another American cement called "selenite," which contains sulphate of lime (plaster of Paris) and is a very quick-setting cement. If any silicate or aluminate of lime forms in this cement it must do so after the sulphuric acid has taken all the lime it can carry, and a little is left over for the silica and alumina.

It is a question open to discussion as to whether it is better to mix up various cementing compounds in any one cement, as they may obstruct or alter each other.

The Cumberland or Upper Potomac cements are all quick-setting natural cements of great merit when fresh, and should be more extensively used.

CLAY.

Clay is a name for a multitude of various stuffs, but it is properly confined to any mixture of silica and alumina in a finely pulverized condition.

Brick Clay is the bottom of the series, and is composed of silica and alumina primarily, but has all sorts of odds and ends of minerals mixed up in it. Burned bricks are nearly always red, and the more brilliantly red they are the more highly they are valued. This coloring matter is iron, and a singular fact in this connection is that the clays which produce the reddest bricks are nearly always yellowish-blue clays. They, of course, contain iron in the carbonate condition, and the burning converts the iron into hematite. A clay which makes a dull, yellowish-colored but otherwise good strong brick can be made to produce a cherry-red brick by using pulverized iron ore in the molding-sand, and this is done in Washington and some other places by using the mineral *Bauxite* mentioned at the end of this sub-chapter. Milwaukee brick are made of a clay containing no iron, and they are cream-colored. This color is becoming fashionable.

Potter's Clay is often made out of brick clay by putting the latter in vats and stirring it with water until the finer clayey portions are suspended in the muddy water. The water is then drawn off and the fine clay is allowed to settle in other vats. A bed of brick clay, if so located as to have the proper slope, can be thus almost entirely washed down into settling vats cut into the clay itself at the bottom of the slope. The stirring vats in these cases are cut into the clay at the top of the slope, and are gradually worked down the slope by cutting and washing the materials of the downhill sides of the vats, while the pebbles and coarse stuff are cast up hill. The muddy water runs down hill either in ground-cut sluices or in troughs.

Beds of nearly pure potter's clay are, of course, more valable to potters than ordinary brick clay, but the difference is not very great, because no clay in nature is found pure enough to make good ware, and it all has to be washed by suspension in water and precipitation, anyhow. Clay beds are, however, found pure enough to make rough, coarse ware out of without washing, and from these come the jugs and crocks and jars and flower pots.

Fire Clays are the clays which are found under the coal beds of the true coals. They generally contain sixty per cent. of silica to thirty of alumina and ten of trash, although many good fire clays differ greatly from these proportions. The fire clays under the coal beds are of almost any color, but bluish or yellowish-gray predominates. The clay is hard and compact and breaks into little cubical blocks, presenting very little appearance of being plastic. Some weathering and working in a pug mill are required to develop its plasticity.

It is mixed with a little sand and burned into bricks, which are used to line all sorts of furnaces where resistance to great heat is required. The stability of the lining of furnaces requires not only that the material shall not melt down, but that it shall not contract or expand under the changing degrees of heat, and this requires that the bricks should be somewhat porous, so as to take up their own "slack." They are, therefore, sometimes made up with fine sawdust or coal dust mixed in the clay, this dust burning out in the kiln and leaving pores all through the body of the brick. Fire clays are found in many other localities besides those mentioned under the coal beds; but it should be borne in mind that any clay already brightly colored, or which contains iron in any form, will never serve for a high-heat fire clay, as the iron acts as a flux for the silica of the clay, forming silicate of iron.

Kaolin is porcelain clay, and it is theoretically pure clay. Its descriptive list is as follows:

Gravity	2.5	Alumina	40 p. ct.
Hardness	1.0	Water	13 p. ct.
Silica	47 p. ct.		

Lustre, pearly to dull; clearness, opaque; color, white to grayish; feel, greasy; elasticity, brittle; cleavage, imperfect; fracture, uneven to conchoidal; texture, earthy and massive, but under microscope is minute scaly.

This clay is the residuum of the decomposition of feldspar. When the potash or other soluble alkali is washed out into the soil, the silica and alumina are left behind as a bed of white clay. Even this clay, found just where it was formed, is rarely so pure that it can be used without washing and refining by suspension in water and subsequent precipitation. It becomes still more impure when Mother Nature supervises the washing, for she cuts it out of the hill with her water sluices and washes it down into beds below, and gets all sorts of impurities mixed in with it, and, worst of all, she is apt to get iron into it. A clay may be a most beautiful white and yet burn into a red or yellowish porcelain, or the clay may be dirty with organic matter and yet burn into a pure white porcelain.

The finest porcelain clays in the world are, undoubtedly, those of China and Japan, and the next are at Limoges, in France. There is recently reported from Northwestern Louisiana a bed of clay which is so fine that French porcelain men are now organizing to use it in new works to be established in New Orleans. The kaolin beds of South Carolina, Maryland, Delaware, and some other American States contain very fine clay, but somehow they don't get up a reputation for themselves, and they have a heavy tariff to secure them against competition, too. The English and French kaolins come to New York in square cakes, stamped with analysis and maker's name, and sell at twenty to twenty-eight dollars per ton, tariff paid. The American kaolins come in bags and barrels and sometimes in bulk, with no analysis or maker's guarantee, and sell at ten to fifteen dollars per ton. This would soon be rectified if American makers would wash, conscientiously, their products, and stamp them so that buyers would know what they were buying.

The surfacing and loading down of writing paper that is not done by barytes is done by kaolin, and its price is thus raised from a clay price to a paper price.

Bauxite is a substance resembling a pure *Fuller's Earth*, and is not properly a clay, as it contains no silica. Its composition is as follows:

Gravity......................2.9	Iron Oxide............27 p. ct.
Hardness 0.8	Water........ ....21 p. ct.
Alumina...............52 p. ct.	

It is a reddish dust, which can be worked up into a paste with water. It is not fusible by any means yet tried. There are deposits of an impure and micaceous variety near Alexandria, Virginia, and the Washington brickmakers use it for molding-sand.

Dinas is the so-called clay out of which the well-known dinas brick is made, and it is almost entirely silica, and, therefore, not properly a clay, but it is marketed as such. It is simply the silicious part of a clay which has been naturally washed.

XIII.

SALTS AND FERTILIZERS.

SALT—SODA—BORAX—SALTPETRE—AMMONIA—GYPSUM—PHOSPHATE ROCKS—POTASH ROCKS—MARL.

SALT.

When a chemical gentleman in spectacles asks for *Halite* or *Sodium Chloride* you may know he means salt, and if he goes on to describe it he will do it nearly this way:

Gravity	2.1 to 2.2	Sodium	39 p. ct.
Hardness	2.5	Chlorine	61 p. ct.

Lustre, vitreous; clearness, sub-transparent; color, colorless, white-yellowish; feel, smooth; elasticity, brittle; cleavage, perfect; fracture, conchoidal; texture, granular, crystalline.

The white and colorless varieties are pure salt, and the reddish, yellowish, bluish, purplish crystals all contain some impurity in slight degree. Lime and magnesia, in the form of chlorides and sulphates, are the most frequent mixtures, but potash is also sometimes present.

Owing to its great solubility, salt is more frequently found in water than as a rock, and most of the salt of commerce is obtained by boiling or otherwise evaporating the waters of the sea or of salt lakes or of salt springs. These springs are, of course, charged with salt during the passage of their waters through underground rock salt. In some European salt mines, where the salt is so much mixed with earth and rock and sand as to make its separation expensive, they dig holes in it and fill them with water, which water they pump out again after it has dissolved enough salt to make its boiling profitable.

The salt in Louisiana is regularly mined dry, while nearly all other American salt is the result of boiling it from brine pumped up from the salt rocks through drilled holes.

SODA.

This is the second strongest of the alkalis, potash being the first. The name soda really means the caustic oxide of the metal sodium, but in commerce it is taken to mean any of three carbonates—the carbonate, the sesqui-carbonate, and the bi-carbonate This last is in most general use, and its points are:

Gravity	1.8	Soda	22 p. ct.
Hardness	2.0	Carbonic Acid & Water,	78 p. ct.

Lustre, vitreous; clearness, translucent; color, white to gray; feel, smooth; elasticity, brittle; cleavage, perfect; fracture, uneven; texture, granular, crystalline.

All three of the carbonates are found in greater or lesser quantities all over the West, and many of the lakes and streams and springs are tainted and alkaline with soda. The straight carbonate sal soda, is the most abundant, and it contains thirty-eight per cent of soda.

The soda lakes of the regions west of the Rocky mountains are a prominent feature in the national economy, and have affected prices all over the world in the three articles of salt, borax, and soda. As these three important minerals are merely compounds of the one substance, soda, they very naturally are all found together. The same basin will hold all three in solution in its water during the rainy season, and will drop them in different layers during each dry season when it dries up.

BORAX.

This is borate of soda, and its points are:

Gravity	1.7	Boric Acid	37 p. ct.
Hardness	2.3	Water	47 p. ct.
Soda	16 p. ct.		

Lustre, resinous to vitreous; clearness, sub-translucent; color, white; feel, harsh; elasticity, brittle to sectile; cleavage, perfect; fracture, conchoidal; texture, crystalline; taste, sweetish.

Borax is found in small quantities in many parts of the world, but the cheapest supply comes from the Borax Lake of California, and from other lakes or dried-up lake basins found among the other curiosities of the lands west of the Rocky mountains. Borax is valuable for many purposes in manufacturing; and there are two kinds, the prismatic and the octahedral—the prismatic having the composition shown above, while the octahedral has only thirty per cent. of water.

The boric or boracic acid is also found native, and is to be looked for in all volcanic regions, and also among salt beds and rocks, and among the gypsum rocks. It is very similar to borax, but it is only half as hard, and a little lighter in weight. It also tastes more acid and less sweet. It is called *Sassolite*, technically. *Sussexite* is a borate of manganese and magnesia, and is much harder and heavier than borax, and has little or no taste, but is white and translucent. *Boracite* is borate of magnesia and chlorine, and is a little heavier and twice as hard as borax. *Ulexite* is borate of lime and soda, weight and hardness about like sassolite, fibrous texture.

SALTPETRE

This is nitre, or potassium nitrate, and contains 39 per cent. of potassium, 14 of nitrogen and 47 of oxygen. It is rarely found native, but its cousins, the nitrates of soda and lime and magnesia, occur in great beds in the rainless upland plains of South America, and the potassium nitrate is easily made from these by substituting potash for the other alkaline bases.

It is not known just how this nitrogen gets into chemical combination with the oxygen in the air so as to form nitric acid, but electricity is believed to have something to with it. Yet, strange as it may seem, all our tremendous expenditures for modern warfare, and for big and little guns, from the 100-ton steel rifle cannon to the 6-ounce Derringer, are based upon the expectation that Nature will continue to combine these gases into acid, so that we can make gunpowder and dynamite and other explosives, with which to kill each other, or make a noise on the 4th of July, and incidentally set fire to our houses.

About one-third of the powder used by the Confederate army during the civil war of 1861–5 was made from nitrate of lime leached out of the dry earth of limestone caverns, the lime being afterwards cut out by home-made carbonate potash, and the resulting saltpetre obtained by boiling and crystallization. This lime nitrate is also found under old houses and out-buildings, and is generated in compost heaps and nitre beds under cover.

AMMONIA.

This is an alkaline gas, and is a product of fermentation or decomposition. It is made up of the gases nitrogen and hydrogen, and can be liquefied by either cold or pressure. The liquid can also be frozen into a white crystalline mass. There are several salts of ammonia, such as the carbonate and the chloride, this last being better known as sal ammoniac. The carbonate is not found as a natural mineral, but the chloride is found occasionally in dry localities, such as nitrates are found in, and can be described thus:

Gravity	2.0 to 2.2	Ammonia	34 p. ct.
Hardness	1.6 to 2.0	Chlorine	67 p. ct.

Lustre, vitreous; clearness, translucent to opaque; color, white; feel, smooth to greasy; elasticity, brittle; cleavage, imperfect; fracture, uneven; texture, granular, crystalline.

A great source of ammonia in all its forms is found in the manufacture of gas. It is formed during the destructive distillation of any of the hydro-carbons, but particularly the bituminous coals. It can be produced by getting up a decomposing disturbance with almost any kind of vegetable or animal substance, and it is the chief valuable constituent in manures, furnishing, as it does, nearly all the nitrogen consumed by plants.

GYPSUM.

This is variously called *Sulphate of Lime*, *Land Plaster*, *Plaster of Paris*, and its points are:

Gravity	2 3	Lime	33 p. ct.
Hardness	1.7	Water	21 p. ct.
Sulphuric Acid	46 p. ct.		

Lustre, vitreous to pearly; clearness, opaque to translucent; color, white, gray, light-yellow; feel, meagre; elasticity, brittle to sectile; cleavage, perfect; fracture, uneven; texture, massive, crystalline.

This mineral occurs in all forms and conditions, from the crystalline *Selenite*, transparent as glass, or the massive *Alabaster*, opaque to sub-translucent and many-tinted, down to the earthy varieties, looking like dirty chalk. *Satin Spar* is a beautiful fibrous variety, with a pearly lustre.

Gypsum is primarily a rock, and a big one, too, for there are beds of it in Southwest Virginia five hundred feet thick and occupying hundreds of square miles of area. This particular bed is not much used for fertilizing purposes, as it is the home of the salt waters of that district, and the salt is mixed with the gypsum.

Gypsum burned and ground like the cements becomes plaster of Paris and "sets" much more quickly, when watered, than any other cement. It is to be looked for as a rock bed and regular member of the limestone groups in all the formations above the primaries.

There is another mineral which is called *Anhydrite*, which often occurs with gypsum, and which is about the same thing as gypsum with the water left out. Its points are:

Gravity....................2.9	Lime..................41 p. ct.
Hardness..................3.3	Sulphuric Acid........59 p. ct.

Lustre, vitreous to pearly; clearness, opaque to translucent; color, white, gray, red; feel, meagre; elasticity, brittle to sectile; cleavage, perfect; fracture, uneven; texture, fibrous, foliated, granular or massive.

This mineral is much harder than the hydrous sulphate, and a little heavier also. The finer varieties are carved into ornamental articles, and the mineral is found in company with the true gypsum. Neither the hydrous nor the anhydrous sulphates effervesce when touched with acids as the lime and other carbonates do.

PHOSPHATE ROCKS.

There are a great many minerals which contain phosphoric acid, and some of them are abundant enough to be of very great importance to mankind. The fact that some of them are of animal origin does not conflict with the other fact that they are also rocks, for when we think about water being simply the liquid form of the rock ice, and that limestone and coal are rocks which were once of purely animal and vegetable matter respectively, we will be ready to concede that bones, carcasses and excrement may become, in time, guano and South Carolina phosphate rocks. We will look first at the earliest of all the phosphate rocks, which is:

Apatite, which is *Phosphate of Lime.*

Gravity....................3.1	Phosphoric Acid......43 p. ct.
Hardness..................4.8	Lime..................55 p. ct.

Lustre, vitreous to resinous; clearness, transparent, all the way to opaque; color, blue-green, but sometimes white-gray or yellow-brown; feel, rough; elasticity, brittle; cleavage, imperfect; fracture, uneven to conchoidal; texture, fibrous to tabular, also granular to massive.

Although the color of this mineral is so various, its powder and streak are always white. It varies greatly in clearness, but the transparent varieties are scarce, and the earthy, opaque textures are also scarce, most of the rock being bluish-green, about sub-translucent and clouded, crystalline. There is always a small percentage of chlorine or fluorine present, and sometimes both.

This rock is found among the older primaries and crystalline rocks. It occurs in veins as a regular vein stone, and in Canada it fills great lenticular-shaped fissures found at intervals over many hundred square miles of territory. It is regularly mined by incorporated companies; and sells readily at thirty-five dollars per ton by the ship-load. It is principally shipped to Europe, where it competes with the best of guano.

This mineral has not been found in any great abundance in the United States, but it has not been thoroughly searched for. There are a number of other phosphates, mentioned below, any of which would reward richly any one who should find them in good quantity.

Wagnerite is phosphate of magnesia, containing 44 per cent. of phosphoric acid, and is very like apatite, slightly harder; color, yellowish.

Triplite is phosphate of iron, manganese and lime, etc., containing 34 per cent. of phosphoric acid. It is also harder than apatite, and is of brownish coloring; sub-translucent.

Ambligonite is phosphate of alumina, lithia, fluorine, and other things, containing 50 per cent. of phosphoric acid. This is 6.0 hard, 3.5 heavy, and otherwise very much like apatite.

Wavellite is phosphate of alumina also, containing 35 per cent. of phosphoric acid. It has 26 per cent. of water in it, and so is only 3.5 hard.

We seriously advise all our readers who are located among the primary rock formations to set up a search for these minerals, as they have never been really looked for in our country, and a good body of them would be a big find for the discoverer. Remember that they are all about one-fifth heavier than quartz, and only about two-thirds as hard, so that quartz will cut them.

Carolina Phosphates are the remains of a lot of fish, etc., that lived in tertiary times along the coast of South Carolina, Georgia and Florida, and probably a great many other places which we have not yet discovered. These fish appear to have made a sort of cemetery of some hundreds of square miles of coast lands, and their remains are in many places piled up several feet in thickness. In many places this stratum of phosphates forms the actual bottom of rivers and estuaries, and is dislodged and raised to the surface by means of dredging machines, while in other places the stratum is overlaid by the tertiary and quaternary clays and sands to such depth as to render the mining very expensive.

These bones and debris have cemented and compacted with each other to such an extent as to be properly called a rock, and it requires much cutting and cracking to detach sharks' teeth and *Coprolites* and other special specimens from the mass. They are now beginning to call this rock mass *Osteolite*, and they sell it by the ship-load in Charleston, or other good seaport, at five to seven dollars per ton. It is only about half as rich in phosphoric acid as apatite.

Down in Florida, along the Gulf coast, and particularly in the valley of the Withlacoochee River, there has recently been discovered an extensive deposit of phosphate stuffs, and much of it appears to be a true phosphatic marl.

Guano, like Carolina phosphates, is the result of animal matter mixed up with enough lime to compact and mineralize it. On the guano islands, the guano on top is still growing by fresh deposits, just as peat is still growing on the top of peat bogs, while down at the bottom of the guano it is a rock, osteolite, with no vestige of animal structure, just as at the bottom of very deep peat bogs, the peat is actually lignite or coal, with no vestige of vegetable structure.

Guano varies in composition greatly, as in the dry climate of Peru there is no rain water to wash and leach out the soluble acids, ammonias, etc., while in rainy climates the insoluble phosphate of lime is all that is left. In order to make good fertilizer out of this plain lime phosphate we have to procure those soluble acids, ammonias, etc., from other sources and put them back in the lime phosphates. The following are two analyses of different guanos, which will show the difference:

Peruvian.		Caribbean.	
Organic Matter	52 p. ct.	Organic Matter	8 p. ct.
Lime Phosphate	23 p. ct.	Lime Phosphate	77 p. ct.
Moisture	15 p. ct.	Moisture	7 p. ct.
Alkaline Salts	6 p. ct.	Lime Sulphate	6 p. ct.
Free Phosphoric Acid,	2 p. ct.	Silica, etc	2 p. ct.
Silica, etc	2 p. ct.		

The Peruvian was worth twice as much as the Caribbean.

POTASH ROCKS.

Potash is one of the elements which go to form a good soil. It is the chief ingredient in the best European fertilizers, but among American farmers it is sadly neglected. The consequence of this is that European land is constantly growing richer, and is now better than when it was first cleared up, fifteen or more centuries ago. English tenant farmers pay twenty dollars per acre per year rent for best wheat lands, whereas the entire crop of our ordinary Pennsylvania wheat lands don't bring much more.

Fertilizers to be complete must contain the ammoniacal or nitrogenous elements, the phosphates and the potashes. Peruvian guano contains the necessary ammonia and phosphates, but does not contain the potash, so the wise European farmers mix the German potash salts with the Peruvian guano, and, verily, they have their reward in big crops and richer lands and advancing valuations. American farmers use fertilizers made up of Carolina phosphates, Caribbean cheap guano, diatoms, and a lot of animal ammoniacal matter, but no potash, and they have their reward, also, in good crops at first, gradually declining into bad ones, and then into sassafras, broom sedge and bankruptcy.

The prime minerals, mica and feldspar, are the sources from which all potash is derived. Some mica contains twelve per cent. of potash, and some feldspar contains seventeen per cent. As these minerals decompose through old age or other causes the potash is released from its silicated condition and forms combinations with chlorine and sulphuric acid, thus becoming a soluble salt. In this condition, and with the aid of water, it permeates all through the soil, and tinctures sea water everywhere. Great beds of chloride and sulphate of potash are found alternating with beds of salt in places where they seem to have been left by the drying up of seas, such as the Dead Sea and others.

Kainite is the sulphate of potash and is the most useful of these salts. It contains, also, other things, as will be seen in the following description:

Gravity	2.7	Sodium Chloride	32 p. ct.
Hardness	2.3	Magnesia Chloride	13 p. ct.
Potash Sulphate	25 p. ct.	Water	14 p. ct.
Magnesia Sulphate	14 p. ct.	Trash	2 p. ct.

Lustre, sub-vitreous to resinous; clearness, translucent; color, ashy-gray; feel, greasy; elasticity, brittle; cleavage, good; fracture, conchoidal; texture, granular, crystalline.

This is kainite as it comes to America, and it has, like all other minerals, a considerable amount of other salts which might be called impurities in some senses of the word. The sodium chloride (common salt), for instance, does very little good to vegetation, and the magnesia chloride does still less, but the magnesia sulphate is of considerable value in causing the perfect seeding of grains and the bolling of cotton. These two chlorides, however, become of value when the kainite is used in composting stable manure, as it retains the ammonia, which would otherwise be lost. They have an excellent effect also when scattered on stall floors and feeding lots.

Kainite is really the definite mineral *Polyhalite*, with such admixture of soda salts as naturally would be deposited with it during its precipitation out of evaporating sea water.

The chloride salts are not an artificial adulteration, and when kainite is used in composting, the chlorides are not an adulteration at all.

Carnallite is chloride of potassium and magnesium, with water. It is also a soluble salt, and its description is as follows:

Gravity......................2.5	Magnesium Chloride..34 p. ct.
Hardness.....................2.1	Water ....39 p. ct.
Potassium Chloride...27 p. ct.	

Lustre, greasy; clearness, translucent; color, white to pinkish; feel, greasy; elasticity, brittle; cleavage, none; fracture, conchoidal; texture, granular, crystalline.

Sylvite is simply pure chloride of potassium, and its descriptive list is as follows:

Gravity......................2.0	Potassium.............52 p. ct.
Hardness 2.0	Chlorine...............48 p. ct.

Lustre, vitreous; clearness, transparent; color, white or colorless; feel, greasy; elasticity, brittle; cleavage, perfect; fracture, conchoidal; texture, crystalline.

This also is a soluble potash salt, although it contains no water of hydration. All three of these—kainite, carnallite and sylvite—are "German potash salts," but this name is more distinctively applied by the trade to the kainite. They abound most plentifully at Strassfurt and at Leopoldshall, in Germany, where they are found in beds intermixed with beds of rock salt over a territorial area of six hundred square miles. Whether they are also to be found around our American salt regions and under Great Salt Lake or the borax lakes of the far West is not yet known.

The kainite is the most used of the above salts, and sells at nine to ten dollars per ton in Baltimore. The chlorides have to undergo a treatment with sulphuric acid to get the very best results, and, therefore, do not sell so high. We think our feldspars or micas might be treated with acid and an economical potassium sulphate produced.

MARL.

This is the lime rock of the tertiary formation, and is to this formation what chalk is to the upper secondary, limestone to the lower secondary, and marble to the primaries. It is soft yet, but if we pile a few miles of new rocks on top of it, and wait, say a few millions of years, it will guarantee any required degree of hardness. It is the work of those tireless infusoria who go on locking up carbon without asking themselves when there will be no more unappropriated carbon to lock up. There are marls which contain phosphoric acid combined with lime, and these are great marls for fertilizing purposes. They are generally granular in texture and greenish in color, and are, therefore, called "green sand marls." The phosphoric acid or phosphate of lime is supposed to come from the great deposits of bones and fish remains found in and about these marls. There are other green marls which contain iron sulphate, and as these sour the land, the amateur fertilizing farmer had better look sharp. The writer has known, however, of several cases in the Patuxent regions of Maryland in which this sour marl was spread and killed everything, but in the third year magnificent crops were produced, and there have been four successive crops since, all good ones, too; from which it would seem that exposure to the weather decomposed the iron sulphate and released the sulphuric acid, which in turn attacked the lime and formed plaster.

This acid marl in the tide-water country along the Atlantic coast is generally a dirty black, and sticky when wet, and contains lignite coal disseminated all through it, but this is rarely of any account, although in former times the sulphuric acid and alum were extracted to some profit while prices were high. Above this black acid marl, which is sometimes as much as sixty to seventy feet thick, the true green sand marl beds are found. This marl is simply soft carbonate of lime with grains of the green mineral glauconite, which is a hydrous silicate of iron and potash which has become changed by phosphoric acid resulting from decomposition of animal remains.

XIV.

MINERAL PAINTS.

OCHRE — UMBER — VERMILION — SMALT — ULTRAMARINE — AQUAMARINE.

OCHRE.

Under this name are grouped a number of substances used as paints, but the iron paints are the only ones which are legitimately entitled to its use.

Red Ochre is the iron ore hematite in the earthy condition. Sometimes it is found naturally in this condition, and is then generally better than when prepared by man, but that is because man is in too much of a hurry and don't put work enough into the pulverization of the ore. But there are instances where this work has been put into it by means of the heaviest machinery, and in these instances the ochre is the finest known. The "dyestone" ore is in the best condition for pulverization. Red ochre can also be made out of limonite ore by first calcining it thoroughly and then pulverizing it.

Brown Ochre is magnetite ore thoroughly pulverized. It makes a very dark and beautiful brown, and is much used.

Yellow Ochre is limonite ore thoroughly pulverized and not calcined. Calcining limonite merely burns out the water and turns the ore into ordinary hematite.

It is obvious that by mixing these ochres any shade of brown, red, or yellow may be produced, and they will all be pure metallic paint, unless some kaolin or other adulterant is put in.

There has recently been utilized a long-known deposit of ochres found in the limonite beds on the Catoctin iron tract, in Maryland, and these ochres are turning out some of the most exquisite colors. The mineral is in the earthy condition, and is separated into different shades by washing, mixing and settling, after which it is dried and triturated or ground. The quality of ochre, apart from its color, depends on the amount of work put into it by either nature or man or both, and its price depends on the market or the ability of the salesman or the interests of the purchaser.

UMBER.

This is, like ochre, a metallic paint, and is simply pulverized manganese oxide. Like ochre, it can be made of different shades by burning or not burning the ores, and then mixing them to order. It is also often mixed with the ochres and produces a purplish paint that is in high favor. Sometimes a very fine umber is found in beds where it has been deposited after having been finely pulverized by Mother Nature, in her kindness, but yet it must be suspended in water and cleared of impurities if wanted for the finest work.

VERMILION.

This is another mineral paint, and is the mercurial ore, cinnabar, in a finely pulverulent condition. It sometimes occurs native in this condition, but never entirely pure, so that man has to either sublime the ore and re-condense it in another vessel, leaving the impurities behind, or he first makes pure mercury and then combines it with pure sulphur, and thus makes a pure cinnabar ore.

Fine vermilion will sometimes lose its sulphur from some unknown cause, and the whole block will turn into metallic mercury, much to the puzzlement of both teacher and pupil in young ladies' art schools.

SMALT.

Smalt is made from the cobalt ores, and is used for the decoration of pottery and porcelain, and glass staining principally. The smalt colors all stand fire well.

ULTRAMARINE.

This is the heavenly-blue color made by finely pulverizing the cuttings from the gems made from the precious stone lapis lazuli, and is a very favorite and high-priced artists' paint.

AQUAMARINE.

This is the lovely green-blue color made by finely pulverizing the cuttings from the gems made from the bluish beryl, or aquamarine stone.

WHITE AND RED LEAD.

These are carbonates and oxides of lead, and must be made artificially in order to meet the requirements of the market.

BARYTIC PAINTS.

These paints are simply pulverized barytes, or barium sulphate.

ZINC WHITE.

This is zinc oxide, and is made artificially.

XV.

GRITS AND SPARS.

TRIPOLI—CORUNDUM—EMERY—NOVACULITE—BARYTES—FELDSPAR—FLUORSPAR—CRYOLITE—STRONTIA.

TRIPOLI.

This is an earth more or less hard and compacted into a semblance of rock. It is composed of the shells of diatoms and other infusoria which use silica for shell-building. Other varieties of infusoria use lime and carbonic acid, and build up limestones when they drop their shells to the sea bottoms.

The merest speck of tripoli, barely visible to the naked eye, if placed under a powerful microscope, will be seen to be composed of some dozens of curious little shapes, spicules, wheels, tripods, etc. Each one of these is a shell, and formerly contained an animal.

These tripolis occur in beds, extending over square miles in area and of many feet in thickness. They are mostly found among the beds of the tertiary formation, but there are some in the upper secondaries. The lowlands called "Tidewater" Virginia and Maryland, contain great quantities of tripoli; and it is also found in Missouri and in Pennsylvania, and among the tertiaries of the Rocky mountains, as electro-silicon.

It is used as an adulterant in fertilizers, and is of some use owing to the presence of ancient animal matter in the shells, shown by the odor when wet. It is also used for polishing powders, the coarser kinds being made up into bricks, and the finer grades being suspended in water like porcelain clay, and assorted into sizes by precipitation in different tanks.

It is also one of the main ingredients in many patent soaps which have a gritty feel, and are great cleaners and polishers.

CORUNDUM.

This is pure alumina, and is the hardest known substance next to diamond.

Gravity	4.0	Aluminum	53 p. ct.
Hardness	9.0	Oxygen	47 p. ct.

Lustre, vitreous; clearness, sub-translucent; color, white, gray, yellow, red; feel, harsh; elasticity, brittle but tough; cleavage, imperfect; texture, granular, crystalline.

This aluminum oxide or alumina is the same material that shows up as sapphire, ruby, etc., under certain conditions, and these are described in the chapter on Precious Stones. Corundum is not transparent, and its lustre is dull, and its colors are not brilliant. It is found among the crystalline rocks (primaries), and its special home is with chrysolite. In Western Carolina, Northern Georgia and Eastern Alabama it is found plentifully in crystals, ranging in size from a mere grain up to several hundred pounds weight.

Emery is an impure corundum, the impurity being iron, either as magnetite or hematite, and the quantities being in various proportions. Emery looks like black iron sand, and it is found in corundum neighborhoods. It will scratch quartz, which iron sand will not do, and it is also somewhat lighter in weight than iron sand. Sometimes it is slightly magnetic.

Corundum and emery vary very much in price. Seventy dollars a ton has been often paid for both of them, and half of that price has been often welcomed by producers. They are used as cutting and polishing powders, the powders of assorted sizes being made up into wheels like grindstones by cementing and molding. Corundum is harder than emery, but emery is the most useful for many purposes, as it fractures into grains with sharp-cutting edges, whereas corundum grains are apt to be roundish.

NOVACULITE.

This is the Arkansas whetstone, and comes from the neighborhood of Hot Springs, where there is a ridge of it reaching many miles to Rockport, on the Ouachita River. It is a white massive silica, and much of it is almost in the condition of hornstone. It is made into the finest honestones or the coarsest whetstones, and all intermediate grades, by proper selection from the stock, but much of it is too much shattered by natural causes to be fit for any use except pulverization, to mix with flint glass or china stock.

BARYTES.

This is called *Heavy Spar* also, on account of its great specific gravity. It descriptive list is as follows:

Gravity	4.5	Baryta	66 p. ct
Hardness	3.1	Sulphuric Acid	34 p. ct.

Lustre, vitreous; clearness, translucent to opaque; color, white, yellowish, reddish, bluish; feel, smooth to harsh; elasticity, brittle; cleavage, perfect; fracture, uneven; texture, tabular.

Barytes is principally used as an adulterant of white lead, but it makes the body of a very good paint of its own. "Pure barytic white lead" was a "trade-mark" which the painters enjoyed some years ago. The heavy twelve-pound paper upon which these words are being written is surfaced and weighted with baryta instead of the usual kaolin, and there is a growing demand for it among the paper mills.

Carbonate of baryta is very similar to the sulphate in nearly all respects, but it is a virulent poison, and should be handled cautiously. It is found nearly everywhere that barytes is found, and it is now coming into use extensively as a substitute for the more expensive soda carbonate in glass-making. A little sulphuric acid put on the carbonate will cause it to froth and effervesce, but will not so affect the barytes.

Barytes occurs in veins in all the primary and lower secondary rocks. Some veins are filled with it, and others have very little, but it is nearly always there.

FELDSPAR.

There are many feldspars, the principal ones being *Anorthite*, *Labradorite*, *Albite*, *Oligoclase*, *Orthoclase*, *Andesite*. The orthoclase is the most abundant, and is, therefore, selected for description.

Gravity	2.7 to 2.9	Alumina	17 p. ct.
Hardness	5.8 to 6.1	Potassa	17 p. ct.
Silica	65 p. ct.	Dirt, etc.	1 p. ct.

Lustre, pearly to vitreous; clearness, translucent; color, white, red, green, pink; feel, smooth to harsh; elasticity, brittle; cleavage, perfect in three directions; fracture, uneven; texture, tabular.

Albite is the soda felspar, and contains silica 69 per cent., alumina 20 and soda 11.

Anorthite is the lime feldspar, and contains silica 43 per cent., alumina 37 and lime 20.

Labradorite is lime soda feldspar, containing silica 53, alumina 30, lime 12 and soda 5 per cent.

Andesite is also lime soda feldspar, containing silica 60, alumina 25, lime 7 and soda 8 per cent.

Oligoclase is also lime soda feldspar, containing silica 62, alumina 24, lime 5 and soda 9 per cent.

Hyalophane is barytic potash feldspar, containing silica 53, alumina 21, baryta 15, potash 8, soda, etc., 3 per cent.

The potash feldspar is the great source from which all our potash comes originally, and potash is made from it even nowadays by man, although Nature has done so much for him by decomposing the feldspar and allowing the potash to get into the soil and thence into vegetation.

Any of these feldspars are used by the makers of what is called "granite ware" and "stone ware" and "stone china." They grind it to impalpable powder and float it in water in vats just as the fine kaolin is treated, and they thus hurry up Nature and get a clay that is very nearly kaolin, without awaiting decomposition. Good clear feldspars are worth from three to five dollars per ton, delivered at the potteries.

FLUORSPAR.

This is fluoride of lime, or, properly speaking, calcium fluoride. Its points are:

Gravity....................3.0	Calcium...............51 p. ct.
Hardness...................4.0	Fluorine..............49 p. ct.

Lustre, vitreous; clearness, translucent; color, white, yellow, green, blue, red, but streak is always white; feel, rough; elasticity, brittle to sectile; cleavage, perfect; fracture, conchoidal to uneven; texture, granular, crystalline.

This spar is much softer than quartz or feldspar, and is thus easily recognized. Its colors are many, and the spar itself is much used as a substance out of which to carve inkstands, paper weights, and all sorts of odds and ends; while the Chinese carve very respectable little devils and idols out of it. It is also the chief source of the fluoric acid used in the arts, and sells at from five to ten dollars per ton. It is found in beds and veins and disseminated crystals among the rocks of the primary formation and the lower secondaries.

Cryolite is fluoride of aluminum and sodium, and its descriptive list is as follows:

Gravity.................... 3.0	Aluminum ....13 p. ct.
Hardness 2.5	Sodium................33 p. ct.
Fluorine..............54 p. ct.	

Lustre, vitreous; clearness, translucent; color, white; feel, smooth; elasticity, brittle; cleavage, perfect; fracture, uneven to conchoidal; texture, massive, crystalline.

The glassmakers in Eastern Pennsylvania pay sometimes thirty dollars a ton for this spar. It all comes from a large vein in gneiss rocks, in Greenland, at the present time, but it has never been systematically hunted for in our own country, and, therefore, it has not been found. Nine-tenths of it that comes here is snowy-white.

STRONTIA.

This is the name commonly given to the nitrate of strontia, very much used in the making of fireworks. It does not occur native, but is derived from the following minerals:

Celestite is sulphate of strontia, and its descriptive list is as follows:

Gravity	3.9 to 4.0	Strontia	56 p. ct.
Hardness	3.0 to 3.4	Sulphuric Acid	44 p. ct.

Lustre, vitreous; clearness, translucent; color, bluish-white to reddish-white; feel, rough; elasticity, brittle; cleavage, perfect; fracture, uneven; texture, fibrous, granular.

This mineral is very handsome, being of just a faint shade of heavenly-blue; hence its name. It does not effervesce under acids, and is found among the secondary formations, also in volcanic countries.

Strontianite is carbonate of strontia, its descriptive list is:

Gravity	3.6	Strontia	70 p. ct.
Hardness	3.8	Carbonic Acid	30 p. ct.

Lustre, vitreous, resinous; clearness, translucent; color, gray, white, yellow, pale green; feel, smoothish; elasticity, brittle; cleavage, perfect; fracture, uneven; texture, fibrous, granular, tabular.

This strontian mineral effervesces under application of acids. Both this and celestite color the flame red when burnt, and both minerals occur in the same neighborhoods.

XVI.

OTHER VALUABLE MINERALS.

Alum—Asbestos—Soapstone—Talc—Sulphur—Graphite—Asphalt—Wax—Mica.

ALUM.

There are many kinds of alum, but the one in common use is the sulphate of potash and alumina. The other alums are those in which the potash is replaced by soda or some other alkaline base. Among these the ammonia alum comes next in importance to the potash alum here described:

Gravity......................1.7	Aluminous Sulphate..36 p. ct.
Hardness....................1.2	Water.................46 p. ct.
Potash Sulphate.......18 p. ct.	

Lustre, vitreous; clearness, translucent; color, white; feel, smooth; elasticity, brittle to sectile; cleavage, imperfect; fracture, uneven; texture, crystalline; taste, puckerish.

Alum occurs native among some of the lower Silurian rocks and shales in Virginia, and among these and the primary shales in many other localities. In England there are beds of shales among the tertiary formations, which shales contain the true potash alum. The owners roast the shales, leach out the alum with water, and then crystallize the alum after evaporation. In this country these shales have not been found, but that is probably because no proper search has been made.

Much American alum is made along the Ohio River by burning and leaching the slates and shales of the coal measures, and "cutting" with potash the solution of sulphate of alumina so obtained. In France and Germany the sulphate of alumina is treated with solutions of the kainite and carnallite potash salts from the Strassfurt mines, in Germany, and even our Ohio River alum-boilers are now beginning to buy these potash salts instead of making their own ashes. There is a large amount of ammonia alum made in Philadelphia by using the waste ammonia from gas works.

ASBESTOS.

This mineral is cousin to hornblende, which was described among compound minerals, but differs in composition, etc., somewhat. Its points are:

Gravity	3.0 to 3.5	Magnesia	29 p. ct.
Hardness	not constant	Lime	6 p. ct.
Silica	59 p. ct.	Alumina and Iron	6 p. ct.

Lustre, pearly; clearness, sub-translucent to opaque; color, gray, white, yellowish, greenish; feel, smooth to greasy; elasticity, flexible; cleavage, perfect; fracture, uneven; texture, fibrous.

There is a variety of this in foliated texture, the sheets being made up of fibres interwoven; and this kind probably gave the first idea of making fire-proof cloth by weaving the fibrous varieties. Some of these finer varieties are so light that they will float on water, and the figure for specific gravity given above does not apply.

Very fine asbestos is of very considerable but very changeable value, as the price which can be realized depends on the humors and fancies of one or two men who have bought or leased most of the valuable known deposits, and thus, with the aid of certain patented processes, they control the asbestos industry of this country. They make roofing paper, fire-proof writing paper, boiler and pipe coverings, and fire-proof paints out of it.

Asbestos is to be looked for among the primary rocks, and particularly in the neighborhood of the serpentine dykes and hills. A cousin of this mineral is *Steatite* or *Soapstone*, which was referred to, under the name of *Talc*, among compound minerals. The finer varieties of soapstone are valuable also for fire-proofing purposes; whole stoves are made out of slabs of this stone, and they give out a much healthier heat than iron plates. By treating the soapstone with sulphuric acid, sulphate of magnesia (Epsom salts) is made in some countries.

TALC.

This group contains *French Chalk*, *Meerschaum*, *Steatite* or *Soapstone*, and *Talc*, which is here described:

Gravity	2.4 to 2.7	Magnesia	32 p. ct.
Hardness	1.0 to 1.2	Water	4 p. ct.
Silica	64 p. ct.		

Lustre, pearly; clearness, translucent to opaque; color, white, gray, green, brown; feel, greasy; elasticity, flexible to brittle; cleavage, perfect; fracture, conchoidal to even; texture, massive, granular, or foliated, sometimes looks like starry radiations as seen in magnesian marble.

Talc is the most abundant of all the great magnesian silicates. The principal gold regions of the world are among the talcose slates of the primary formation.

SULPHUR.

This is sometimes called *Brimstone*, and it is not so long ago that it was popularly supposed to have reached the earth's surface by being blown out through the volcanic chimneys of the Inferno, during stirring times down there, caused by the chief engineer encouraging his lazy firemen. Its description is as follows:

Gravity	2.0	Sulphur	100 p. ct.
Hardness	2.0		

Lustre, resinous to vitreous; clearness, sub-translucent; color, yellow, faintly greenish; feel, smooth; elasticity, sectile to brittle; cleavage, imperfect; fracture, conchoidal; texture, massive, crystalline.

Sulphur is found native in many localities, but principally in the neighborhood of volcanoes, active or extinct. It exists also among the clays and marls of the tertiary formations, sometimes native, but mostly as sulphate of iron or free sulphuric acid. The great beds of gypsum (sulphate of lime) contain probably more sulphur than all other formations on the earth's surface.

Sulphur is obtained by melting the volcanic rocks and ashy masses containing it, and the sulphur runs out like melting lead out of galena. Sometimes it is distilled in vapor and condensed as pure "flowers of sulphur." It is also made from iron pyrite ores; but as these ores are chemical compounds and not mere mixtures, the sulphur takes up oxygen and the proceeses become intricate and require a chemist.

The demand for sulphur for use in acid-making is recently being interfered with by the men who burn iron pyrite ores for this purpose.

GRAPHITE.

This is generally called *Black Lead* or *Plumbago*, and its description is this:

Gravity .... 2.0 to 2.2		Carbon .... 100 p. ct.
Hardness .... 1.2 to 1.9		

Lustre, metallic; clearness, opaque; color, black; feel, greasy; elasticity, sectile to flexible; cleavage, perfect; fracture, uneven; texture, foliated.

Sometimes its texture is earthy, with little or no lustre; but it becomes lustrous when rubbed. It is never actually pure, there being always a little iron or other grit mixed up with it. In order to use it for the making of lead pencils, and for lubricating purposes, it must be suspended in water, like the finest porcelain clay; when the grit, being heavier, drops to the bottom, and the liquid is drawn off to other tanks. Sometimes it is ground and floated off several times, to make the leads for finer grade pencils. The sediment is mixed with very little refined clay for soft pencils, and with more for harder pencils, and is squirted out of a syringe, and cut off at proper lengths.

Graphite is the best material known for making unburnable crucibles out of, although it is really the earliest of the coal formations. It is found down among the primary rocks, and, although the good beds of it are owned by the present monopolies, yet there may be other good beds found and other monopolies formed.

ASPHALT.

Asphalt is a hydro-carbon, and is found in such situations, in this country, as to justify the belief that it is the solid portion of petroleum left after the evaporation of the volatile portion. The great Pitch Lake, in Trinidad, however, is believed, by many observers, to be merely an ancient peat-bog, which, under tropical or subterranean heat, has been melted into pitch and asphalt, instead of having been compacted into lignite or coal. It varies considerably in its composition and physical features, so we will not attempt to give a descriptive list of it, but will merely recommend our readers to secure quickly any deposit of any substance that looks and smells like pitch or tar, as it is likely to be asphalt, and is becoming more valuable yearly.

In Europe there are beds of limestone, containing a percentage of asphalt, distributed all through the stone, and this stone, crushed and molded into blocks, or crushed and rolled hot in place, is the basis of the now fashionable Parisian pavement. These limestones are in the secondary formations, and it would be well to keep an eye open for similar beds in this country. The skunk limestones of the Devonian rocks, in Tennessee, may turn out to be worth something in this direction. The artificial asphalt block pavement, when made of *anhydrous non-crystalline* limestone and well-burned asphalt, is a really first-class pavement.

Mineral Wax, sometimes called ozokerite and other hard names, is, like paraffine, derived from petroleum, but by natural processes instead of artificial, and is to be looked for in rock cavities from which oil has escaped or evaporated. It is in great demand among the electricians for insulating purposes

MICA.

This is a large group, the principal members of which are named *Biotite*, *Phlogopite* and *Muscovite.* The latter is the most common and abundant, and is selected for description.

Gravity	2.7 to 3.1	Potassa	9 p. ct.
Hardness	2.0 to 2.5	Water	4 p. ct.
Alumina	34 p. ct.	Sundries	6 p. ct.
Silica	47 p. ct.		

Lustre, pearly; clearness, translucent to transparent; color, white, green, yellow, black; feel, smooth; elasticity, flexible to elastic; cleavage, perfect; fracture, uneven; texture, foliated.

The coloring matter of the micas is usually iron, and often a part of the potassa is replaced by soda. Mica is one of the principal ingredients of the true granite, in which rock it is easily distinguished in little bundles of plates or scales. Sometimes it is in large pockets in granite or gneiss rocks, and then can be split up into transparent plates, which are used for stove plates or windows. Some people call it *isinglass.*

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der
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für das
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POCKET GEOLOGIST.